POWER

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A Pinching, Saving Time

There are but two ways of paying debt—increase of industry in raising income, increase of thrift in laying out.—CARLYLE.

WE HAVE a debt to pay. A five months strike has cost the coal producers millions in extraordinary expenses and loss of profits and the miners millions more in lost wages.

Justly or injustly, we who use coal have got to pay the damage.

And, worse than this, our ability to pay is likely to be impaired by our inability to get fuel with which to maintain our earning power.

There has never been a time even in the stringency of war when it was more imperative to make the best use of what fuel is available than now.

When, as in ordinary times, the cost of power is but a small percentage of conducting an industry, the manager is prone to overlook the economies that may be effected in his power plant; but when it becomes a question of being able to run at all, the power question takes on a new significance.

Careful thought and much ingenuity are expended upon the various processes of manufacture, careful account is kept of the cost of the successive steps in production, but the power situation gets attention only when it gets so bad that it hurts.

I have a friend who, exasperated by the avoidable wastes that he sees going on in the power plants about him, says: "When a man is losing money and doesn't know it, it doesn't worry him."

Perhaps that is the reason that many managers take it so ungraciously when their engineers or others point out the savings that could be made in their power plants. They want to go on unworried.

We are 50,000,000 tons behind in our supply of industrial fuel. The deficiency cannot be made up in months. The situation is complicated by the crippled condition of the railroads due to another strike.

We have got to get along with less coal, and unless we can make tnat less coal go further we will be able to do less work, which means lessened profits, red ink, unemployment and an extension of the depression from which we were beginning to recover.

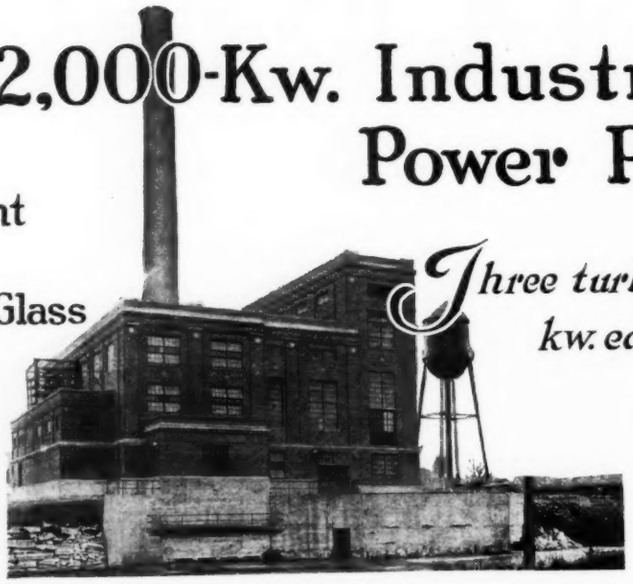
Every user of coal, therefore, in his own selfish interest, to say nothing of public-spirited and broader social-economical motives, should assure himself that no wastes that can possibly be avoided are occurring in his power-producing and heat-using processes.

An indication of what can be done is furnished by the experience of a manufacturing city during the war. Through the activities of a committee of engineers and combustion specialists the fuel consumption of its industries was cut nearly in two with no diminution in their production.

There is a difference between the conditions then and now. New apparatus was unobtainable; the old apparatus was working at its limit. The problem was to keep going and to produce. In this time of slackened demand there is a chance for overhauling and reorganization. More efficient apparatus and appliances that will save fuel and steam are obtainable at ordinary prices and for prompt delivery. Their installment now will help in the present crisis, and the economies that they effect will be a continuing element in that "thrift in laying out" which will help us to recover the losses of war, militaristic and industrial.

A 12,000-Kw. Industrial Power Plant

Kokomo Plant *of the* Pittsburgh Plate Glass Company



Three turbine units of 4,000 kw. each supply 2,300-volt power to factory substation

PREVIOUS to the construction of this 12,000-kw. power station at the Kokomo Indiana Plant of the Pittsburgh Plate Glass Co., the source of power for the factory consisted of a producer gas engine plant and a steam plant. The latter contained an old vertical turbine, reciprocating steam engine, direct-acting steam pumping equipment and hand-fired boilers. The current generated by both plants was 25-cycle.

In 1919 the Pittsburgh Plate Glass Co. found it necessary to increase the speed and horsepower of the motor drives, and inasmuch as these motors constituted practically the whole power installation in the factory, it was an easy matter at the same time to change to 60-cycle current. This change in current characteristics was desirable on account of the lower first cost and better delivery of 60-cycle motor equipment. The factory conditions made it necessary to change over the motors in the shortest possible time.

Requirements of manufacturing extension rendered the centrally located space occupied by the gas-engine plant more valuable for factory purposes than that of power production. Furthermore, both the old gas-engine plant and steam plant were uneconomical in fuel consumption and labor. Maintenance costs of these old plants was comparatively high, especially in the gas-engine plant. Purchased power was out of the question in this case, as the power requirements of the plate glass works were in excess of what could be obtained at the time from the station supplying power for Kokomo.

The desirability of constructing a new power station became obvious, and in the latter part of 1919, Stone & Webster, Inc., were instructed to proceed with the design and construction of a new 12,000-kw. power station. Reliable and flexible operation is represented in three main units and six boilers, where the advantages of duplicating apparatus have been fully utilized. The location on Wild Cat Creek in the outskirts of Kokomo, is one thousand feet from the factory of the Pittsburgh Plate Glass Co., in which a substation is installed.

The power station building is of steel-frame construction on spread footings, no piles being used. The walls are of red brick with precast concrete trim. The floors are of concrete, those in the turbine room having a red quarry tile surface, and those in the boiler room a granolithic finish. In the turbine room the walls are faced on the inside with a buff-colored brick with a sanitary-tile base. Precast gypsum with tar and gravel covering is employed for the roof. The turbine room is approximately 137 ft. long and 40 ft. wide. The three 4,000-kw. turbo-generators are placed longitudinally with their axes in one line, and with the two exciters, constitute the only equipment at the turbine-room floor level. This floor is really only a platform along the sides of the turbines and along the wall next the electrical bay, permitting ample natural light to reach the condenser floor, which is where all the auxiliary equipment is located and which is really the main operating floor. A railroad track into the building at the condenser-floor level permits heavy pieces of equipment to be unloaded by the turbine-room crane.

The boiler room is 132x56½ ft. and contains space for six 6,650-sq.ft. B. & W. boilers. This is an allowance of slightly less than ⅛ sq.ft. of floor space per square foot of heating surface. Each boiler has three 42-in. longitudinal drums and 294 four-inch tubes 20 ft. long arranged 14 tubes high and 21 tubes wide. The boilers are set in batteries of two with their front headers 13 ft. above the boiler-room floor. A superheater is placed over the first and second pass of each boiler and is designed to superheat the steam 125 deg. (522 deg. total temperature). The working pressure is 225 lb. gage. Inclined baffles and seven-element soot blowers are employed.

Three-ram extra-long type underfeed stokers were selected with special reference to the coal to be burned, which has a low fusing temperature and a high percentage of sulphur. Each has seven retorts with an effective grate area of 136 sq.ft. Cast-iron side-wall boxes and pressure water backs prevent adherence of clinker to side and bridge walls. The stokers are driven from a common lineshaft which is in turn driven by two vertical inclosed engines, one being a spare.

Forced draft is provided by two turbine-driven fans of 75,000 c.f.m. capacity each. The fans discharge into a steel-plate duct under the boiler-room floor, from which branch ducts connect with the windboxes of the underfeed stokers.

The stack is of radial brick 12 ft. in diameter at the top and extends 230 ft. above the concrete foundation at ground level, or 207 ft. above the grates. A ⅜-in. steel-plate flue with semi-circular top on the roof of the boiler room connects with the stack. The area of the flue at the entrance to the stack is 132 sq.ft. Up-

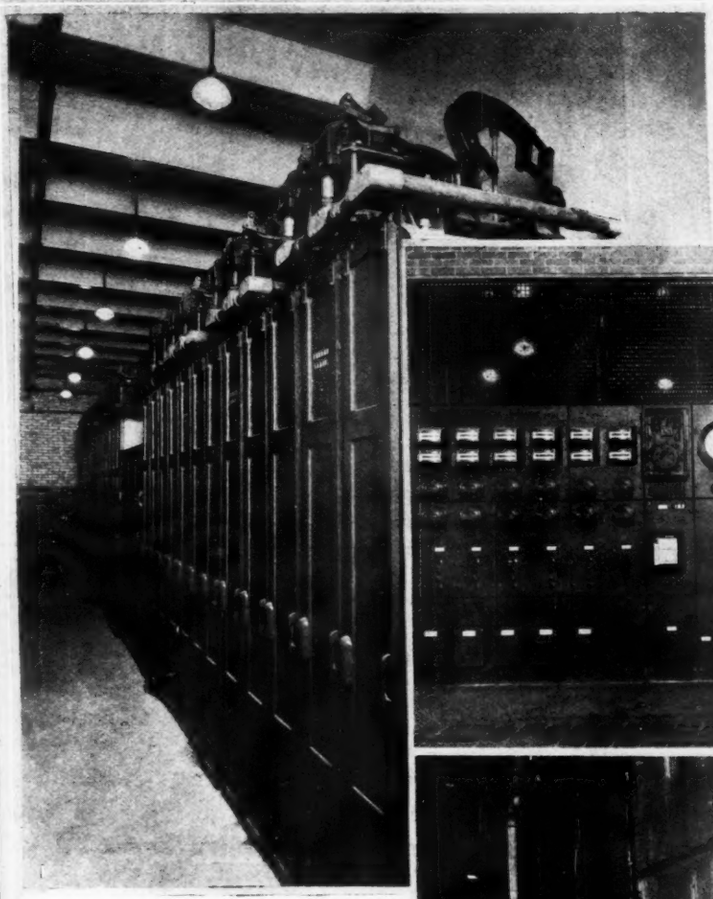


FIG. 1—Solenoid operated, 2,300-volt oil switches are mounted in concrete cells. A concrete structure integral with the switch cells contains a 2,300-volt three-phase bus.

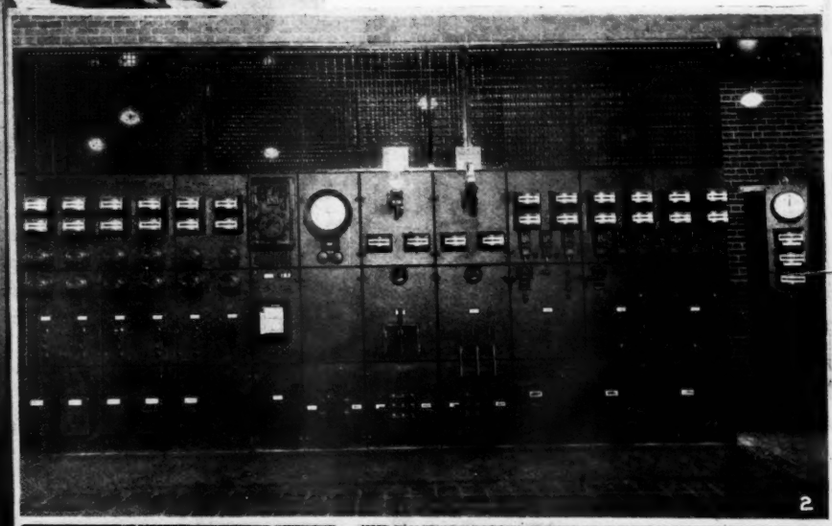
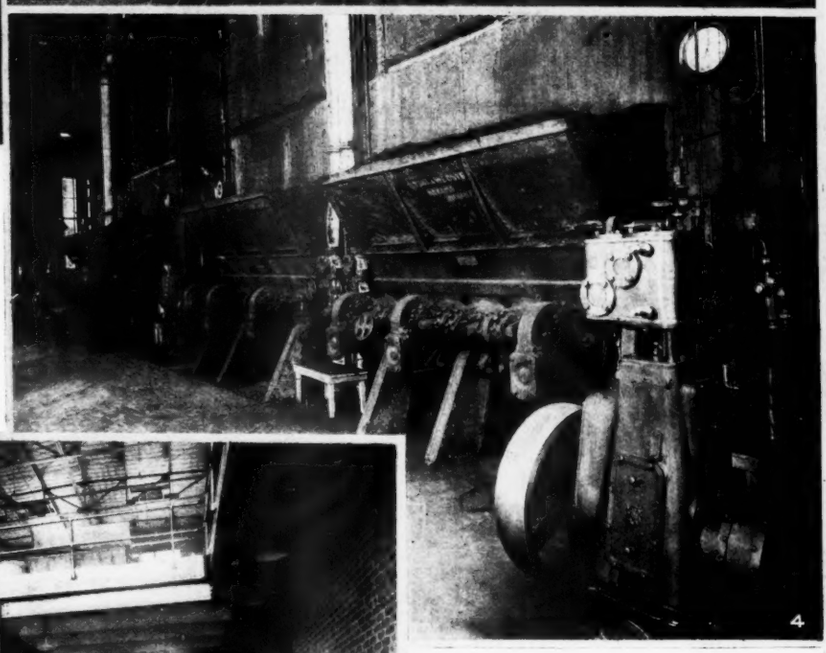


FIG. 2—The main switchboard consists of ten vertical slate panels, controlling the solenoid switches. An auxiliary distribution board of 13 panels is placed adjacent, but not shown in the illustration. The latter contains hand-operated 2,300-volt switches and an auxiliary bus on pipe framework, mounted on the rear. The bus is divided into two sections, controlling the station auxiliaries from one and factory light and power from the other.



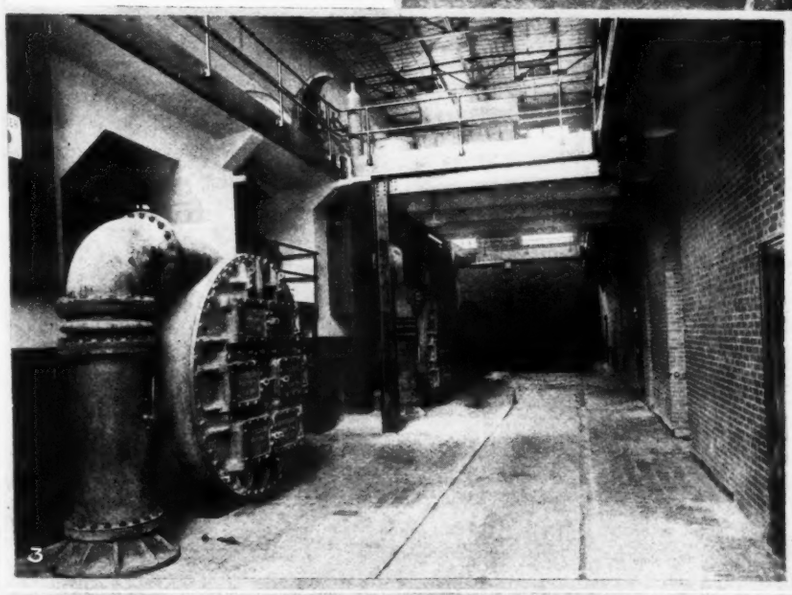


FIG. 3—Three-pass surface condensers, each containing 9,000 sq.ft. of 1-in. Muntz-metal tubes, serve each turbine. Sixteen-inch double suction volute pumps furnish circulating water, while vacuum is maintained by turbine-driven rotative dry pumps. Note that condenser pit is practically open to light from above.

FIG. 4—Extra long, three-ram underfeed stokers are especially built for burning high-sulphur coal with a low fusing temperature. A weighing larry measures the coal supplied.

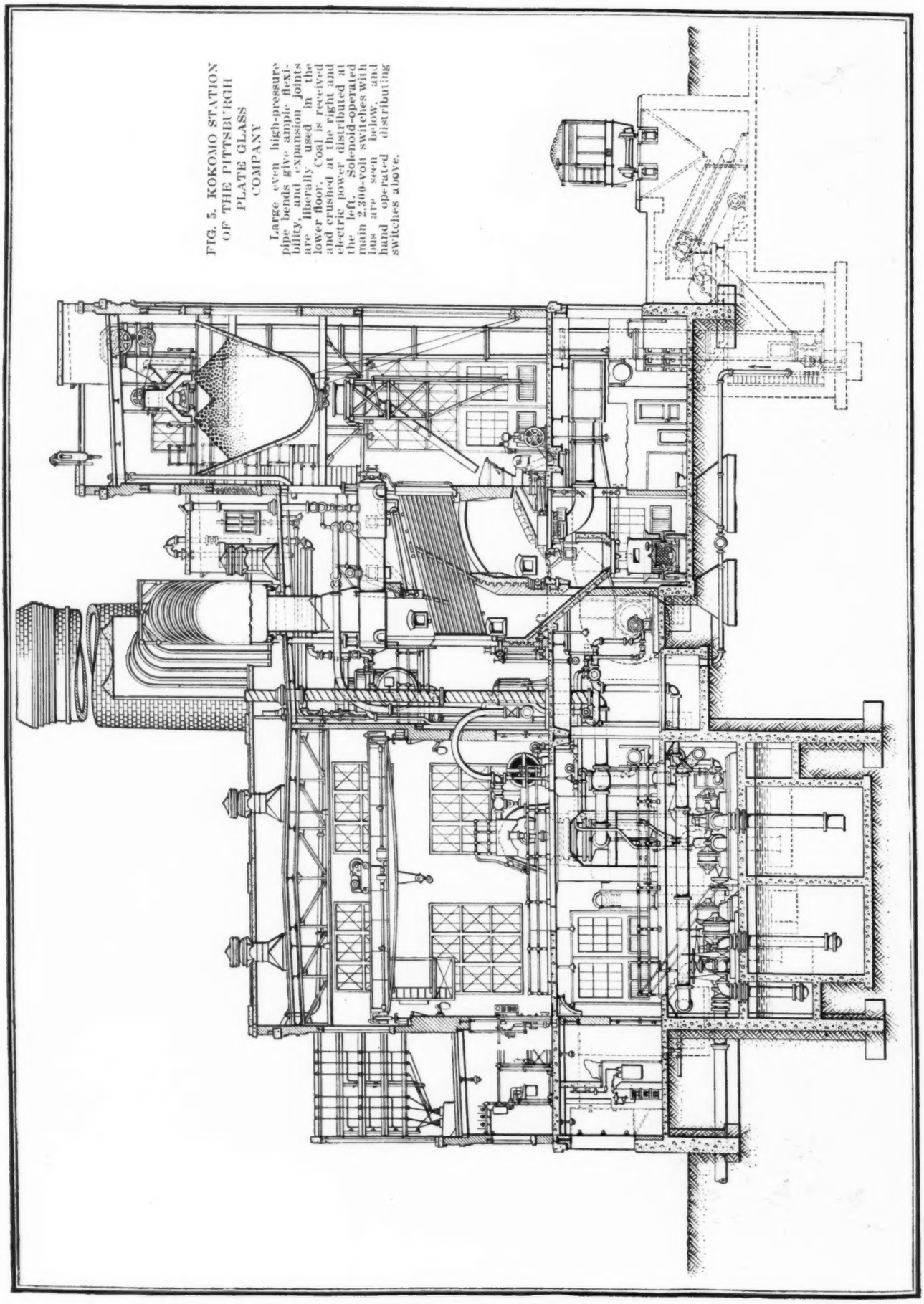


FIG. 5. KOKOMO STATION OF THE PITTSBURGH PLATE GLASS COMPANY

Large cast-iron high-pressure pipe bends give ample flexibility, and expansion joints are liberally used in the lower floor. Coal is received and crushed at the right and electric power distributed at the left. Solenoid-operated main 2,300-volt switches with bus are seen below, and hand operated distributing switches above.

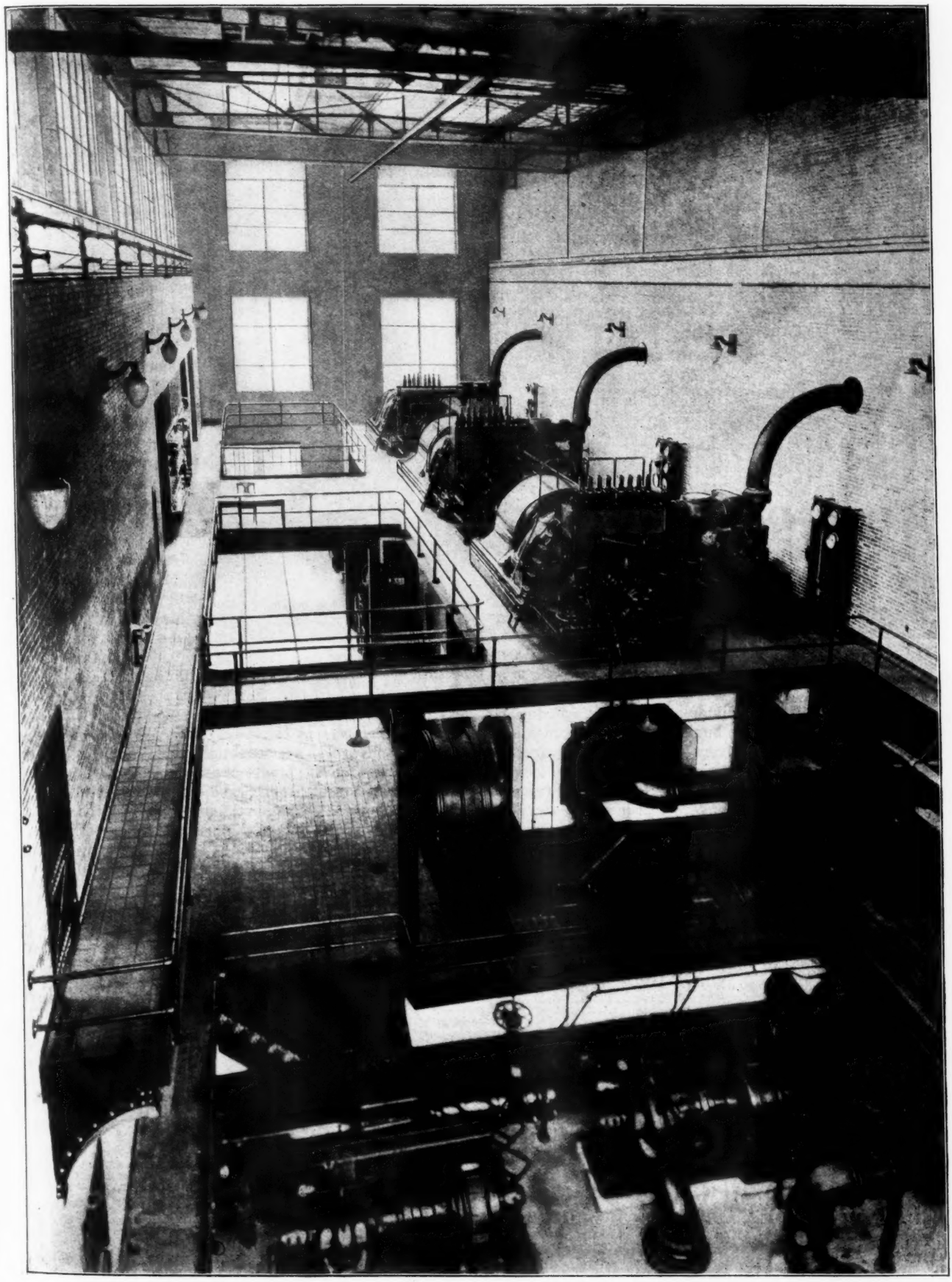


FIG. 6—TURBINE ROOM, SHOWING ELECTRICAL CRANE AVAILABLE TO AUXILIARIES IN BASEMENT

takes leave the boiler settings at the tops of the drums, each uptake having 30 sq.ft. area.

Coal is received in railroad cars and delivered to a track hopper having a capacity of 20 tons. The coal is fed from the hoppers to an inclined apron feeder, which delivers it to a 30x30-in. single-roll crusher. From the crusher it is carried to the bunker level by a continuous bucket elevator which delivers to a belt conveyor that distributes the coal to the concrete-lined bunker, located over the firing aisle, by means of a self-propelling tripper. The coal is fed from the bunkers to the stoker hoppers by means of a traveling weigh larry having a capacity of 4,000 lb. of crushed coal. All this coal-handling equipment is motor driven, and the capacity of the system is 60 tons an hour. For unloading and reclaiming coal in the storage yard a 15-ton locomotive crane is provided with a 1½-yd. grab bucket. Ashes from the stokers are discharged into hoppers which dump into a standard motor truck for removal. Soot from the combustion chambers of the boilers is handled in a similar manner.

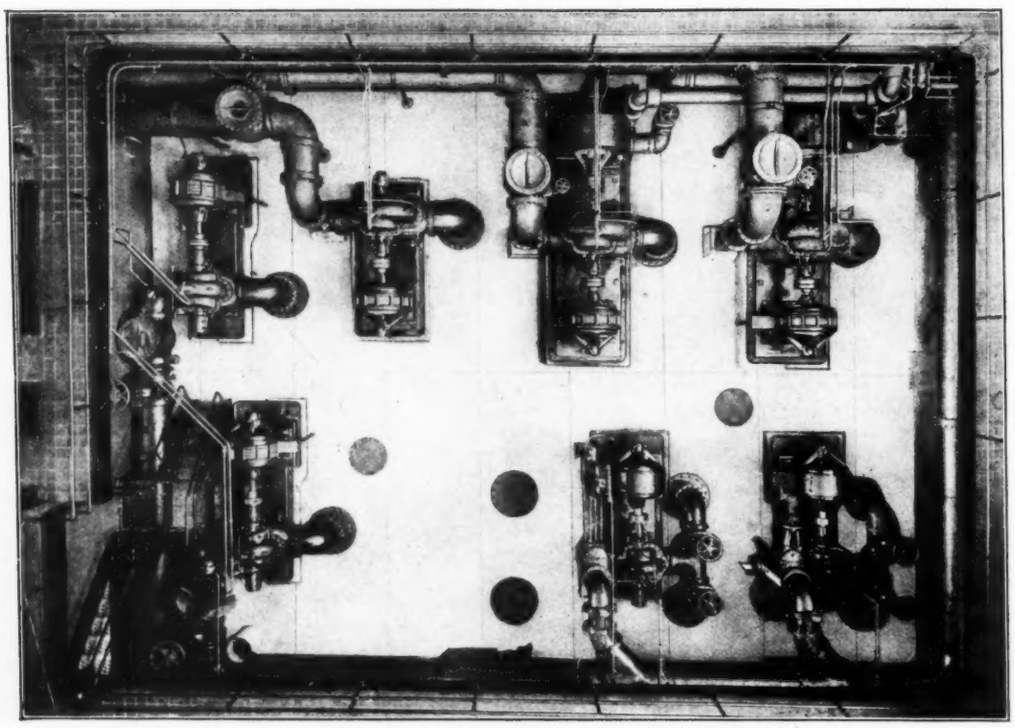


FIG. 7—SERVICE, CIRCULATING AND SPRAY PUMPS
These are adjacent to screenhouse, relieving usual congestion at condensers

The three steam turbines are of the horizontal Curtis type, operating at 3,600 r.p.m. They are designed for 225 lb. steam-pressure with 125 deg. superheat. The generators are three-phase, 60-cycle machines rated at 4,000 kw. at 80 per cent power factor and deliver current at 2,300 volts. Each turbine is served by a three-pass surface condenser containing 9,000 sq.ft. of cooling surface. The tubes are 1-in. seamless drawn Muntz metal, and this composition is also used for the tube plates.

Two condensers are each provided with a 16-in. double-suction volute pump, capable of circulating 7,600 gal. of water per minute, and connected to a 75-hp. turbine and an induction motor. The third condenser has a similar pump driven by an induction motor. Each

PRINCIPAL EQUIPMENT OF KOKOMO POWER STATION, PITTSBURGH PLATE GLASS CO.

No.	Equipment	Size	Operating Conditions	Maker
1	Locomotive crane	15-ton 1.5-yd. bucket,	Handles storage and reclaimed coal	Brown Hoist Mchy. Co.
1	Single-roll crusher	30in. x 30in. 60 tons per hr.	Motor-driven	Stephens-Adamson Mfg. Co.
1	Fixed bucket conveyor	60 tons per hr.	Motor-driven to bunker	Stephens-Adamson Mfg. Co.
1	Belt conveyor with propelling tripper	20-in.	Motor-driven. Distributes coal in bunker	Stephens-Adamson Mfg. Co.
1	Weighing larry	2-ton	Motor-driven	Stephens-Adamson Mfg. Co.
6	Underfeed stokers	7-retort	Driven by engines	American Eng. Co.
6	Long-drum water-tube boilers	6650-sq. ft.	225 lb. sq. in. gage	Babcock & Wilcox Co.
6	Foster Radiant superheaters		Placed on rear fire wall 125 deg. super heat	Power Specialty Co.
2	Radial-flow double-inlet fans, forced draft	75,000 cu. ft. per min.	Connected to Terry turbine	Green Fuel Econ. Co.
1	Radial brick stack	230 ft. high, 12 ft. dia.		Custodis Chimney Cons. Co.
4	Traveling screens	48-in.	Motor-driven	Link Belt Co.
2	S. stage centrifugal service pumps	12-in.	Motor-driven	DeLaval Co.
1	Hot process softener	1,600-gal. per hr.	Treats makeup water	Harrison S. B. Works-Cochrane
1	Open heater	5,000-hp.	Exhaust steam, 210 deg.	Harrison S. B. Works-Cochrane
2	Boiler-feed pumps	300 gal. per min. Three-stage double suction	Driven by Terry turbine	Worthington Pump & Mach. Corp.
3	Horizontal-impulse turbines	4,000-kw.	225 lb. gage, 125 deg. super heat	General Elec. Co.
3	Three-phase, 60-cycle generators	4,000-kw.	2,300 volts, 3,600 r.p.m.	General Elec. Co.
3	Surface, three-pass condensers	9,000-sq.ft.	27-28 in. vacuum	C. H. Wheeler Mfg. Co.
2	Double-suction volute pumps for cooling water	16-in. 7,600-gal. per min.	Driven by 75-hp. Terry turbine or induction motor	C. H. Wheeler Mfg. Co.
1	Double-suction volute pump for cooling water	16-in. 7,600-gal. per min.	Driven by 75-hp. induction motor	C. H. Wheeler Mfg. Co.
3	Two-stage centrifugal pumps, for condensate	4-in.	Driven by 25-hp. Terry turbine	C. H. Wheeler Mfg. Co.
3	Single-stage rotative dry vacuum pumps	8x18x16 in.	Driven by 25-hp. Terry turbine	C. H. Wheeler Mfg. Co.
1	Traveling crane in turbine room	30-ton	3-motor, 38-ft. span	Milwaukee El. C. & Mfg. Co.
2	Single-stage centrifugal spray pumps	7,600-gal.	Driven by 150-hp. induction motor	DeLaval St. Turb. Co.
1	Turbine nozzle spray equipment	15,000-gal.	6 lb. pressure	Spray Eng. Co.
1	Duplex exciter set	90-kw.	Driven by 135-hp. Terry turbine or induction motor	General Electric Co.
1	Motor-generator exciter set	90-kw.	Driven by 135-hp. induction motor	General Electric Co.
1	Main switchboard	10 panels	Controls solenoid switches	General Electric Co.
1	Auxiliary switchboard	13 panels	Contains hand switches	General Electric Co.
3	2300/220 v. transformers	50 kw. each	Three-phase bank supplies auxiliary power	General Electric Co.
6	"Stets" boiler feed regulators	Type B	Holds water level	Williams Gage Co.
2	Feed pump regulators	Excess pressure type	Governs boilerfeed	Fisher Governor Co.
	Motor drives	Induction motors	For auxiliaries	General Electric Co.

Note: Piping and valves were furnished by a number of companies.

condenser is equipped with a 4-in. two-stage turbine-driven pump for the removal of the condensate. The air pumps are the rotative dry vacuum type 8x18x16-in.

Circulating water is obtained from the adjacent stream, Wild Cat Creek, and as the flow is inadequate during the summer months, a spray pond is used for recooling the water. Two motor-driven centrifugal pumps with capacity of 7,600 r.p.m. each, circulate the water through 400 center-jet spray nozzles, operating at a pressure of 6 lb. per sq.in. The system is designed to cool 15,000 gal. per min. under normal conditions of air temperature and humidity.

Stationary racks and motor-driven revolving screens are provided at the screenhouse, and water is conducted to the circulating pumps and returned from the condensers through concrete tunnels.

Makeup water for the boiler feed is taken from the creek and, after passing through a hot-process softener, is delivered through a surge tank to the open heater. Two three-stage double-suction turbine-driven centrifugal pumps, rated at 300 gal. per min. each, handle the boiler feed. The feed-water supply is controlled by pump governors and feed-water regulators.

All high-pressure piping is designed for 225 lb. pressure and 125 deg. superheat. Van Stone joints are used, and all valves and fittings are steel, the valves being trimmed with Monel metal. Long-radius bends and expansion loops are provided to care for expansion. The main and auxiliary headers are sectionalized to provide for emergencies in operation. Automatic non-return valves are installed at each boiler.

A duplex turbine and motor-driven exciter having a capacity of 90 kw. is normally used for the excitation of the main units. A turbine-driven exciter of similar capacity is installed for relay service.

Switchboard Equipment

The main switchboard consists of a ten-panel vertical slate board with remote-control solenoid-operated oil circuit-breakers mounted in concrete cells. The auxiliary switchboard is a thirteen-panel vertical slate board with hand-operated oil circuit-breakers, mounted on pipe framework directly back of the panels. There is a single three-phase main bus installed in a concrete structure integral with the circuit-breaker cells. The auxiliary bus is open and is mounted on a pipe framework at the rear of the auxiliary switchboard. It is divided into two sections, one of which controls the station auxiliaries and the other is used for factory light and power, including the water supply pumps which are installed in the power house.

Feeder cables leave the electric bay overhead and are carried to the factory substations on a steel-tower transmission line. The factory power load is carried on three main circuits, each of which consists of two 350,000-circ.-mil bare cables per phase. In addition a 2,300-volt lighting circuit and a miscellaneous power circuit are carried upon the towers.

The larger auxiliaries are equipped with 2,300-volt motors, while the smaller motors are 220-volt. A bank of three 50-kw. transformers supplies the 220-volt motors and the station lighting system which is three-wire. Double-throw switches are provided on the main switchboard so that the lighting circuits can be operated from the station transformer or from the exciters in an emergency.

Protection against damage caused by faults originating in the generator windings is provided by differential relays which are operated from current transformers connected within the delta of each generator. Temperature indicators are installed in each generator.

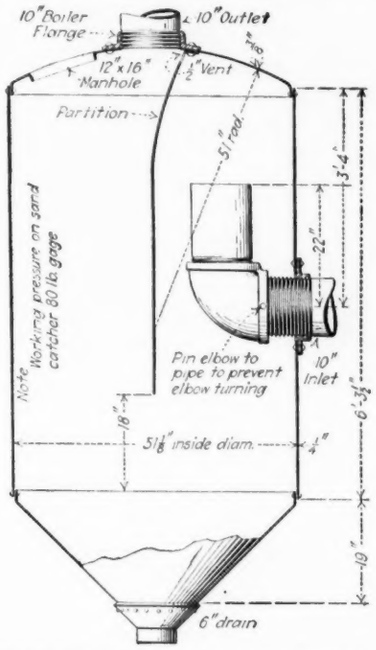
Two 16-in. double-action single-stage motor-driven pumps furnish service water for the power station and glass factory. These pumps are so arranged that either cold water, warm water from the condenser discharge tunnel or any mixture of both may be supplied. These service pumps, together with the circulating-water and spray-pond pumps, are installed in an open pit at the end of the plant adjacent to the screen well house (see Fig. 7). This arrangement relieves the congestion usually found around surface condensers where the circulating-water pumps are located adjacent to each condenser.

Hand-controlled heat balance is obtained by operating some of the main auxiliaries with motor or turbine drive. Two of the circulating pumps and one of the exciters are equipped with combination drives.

A Separator for Removing Sand from Water

By Claude C. Brown

In the industrial plant with which I am connected, approximately three million gallons of fresh water is used every twenty-four hours. This water is pumped



SAND PRECIPITATES FROM WATER WHILE PASSING THROUGH SEPARATOR

from storage tanks by centrifugal pumps and is discharged through sand filters to the house distribution line. Some time ago considerable trouble developed due to some sand passing over with the water, and it became necessary to provide some means of removing this sand. Accordingly, a separator was constructed and installed on the discharge of the filters.

The separator consists essentially of a steel shell of the dimensions given, fitted with a baffle and inlet and outlet connections as shown. The sand is precipitated from the water while passing around the lower end of the baffle and settles in the bottom, whence it is flushed into an open funnel every eight hours, and the quantity of sand noted.

Locating Faults in Direct-Current Armatures—Testing for Grounds in Parallel Windings*

Effects of Grounds in Armature Windings Explained—Test for Grounded Windings With Lamp Circuit—Testing to Locate Grounded Coils with a Low-Reading Voltmeter

By B. A. BRIGGS

GROUNDS in an armature may produce a number of effects. If the frame of the machine is grounded and there is a ground on the power system, a ground occurring in the armature winding or commutator will cause the protective device to open. In medium- and large-sized machines a failure of the armature insulation is sometimes attended with disastrous results to the winding and core, since they may be badly burned where the failure occurs. Where there is no ground on the system, or the frame of the machine is insulated, a ground on one turn in a coil or on one commutator segment will have no ill effects upon the machine's operation. However, these defects generally soon spread to adjacent parts and cause trouble. When

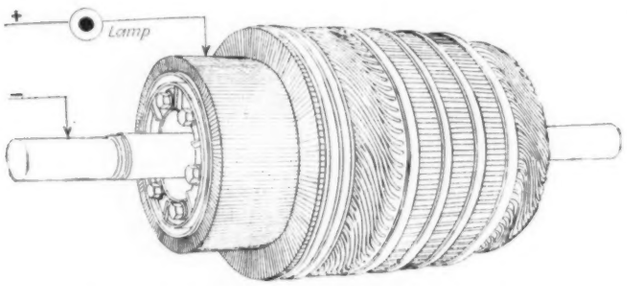


FIG. 1—TESTING ARMATURES WITH LAMP FOR GROUNDS

two or more turns are grounded in the same coil, this will have the same effect as a short-circuit between turns of the coil. Likewise a ground between adjacent segments in the commutator is the same as a short-circuit between segments. A ground on two different coils in the winding would be the same as a short-circuit on a group of coils.

When a ground exists in an armature, it can be easily determined with a test lamp by connecting one terminal to the shaft or core of the armature and the other to the commutator, as in Fig. 1. The coils all being connected together to form a continuous circuit, it does not make any difference which commutator segment is touched, a light will be obtained if a ground exists. In Fig. 2, if coil 10 is grounded to the core at X, then if one terminal of the test circuit is connected to the core and the other to segment 4, one circuit will be from segment 4 through coils 4, 5, etc., to segment 10, through part of coil 10 to the ground at X, and from X through the core to the negative side of the line. Another circuit is from segment 4 through coils 3, 2, 1 to G, coils 24, 23, etc., to segment 11, then through the other part of coil 10 to the ground at X through the core to the negative side of the line. From this it is evident that although the lighting of the lamp indicates a ground in the winding, it does not give any indication as to what coil is defective or how many may be at fault. The ground might have been on any one of the coils and the lamp would have lighted just the same as when coil 10 was defective

To locate the exact coil or coils that are at fault, a low-reading voltmeter or telephone receiver must be used. In making this test a current is passed through the winding as when testing for short-circuits or open-circuits, as indicated in Fig. 3. The current should be adjusted to a value that will cause a throw on the voltmeter of about one-quarter scale when connected to two adjacent coils, as at H. After this has been done, one terminal of the voltmeter is connected to the core, as at Y, and with the other terminal the commutator segments are touched. Care should be taken in doing this, for the meter needle may be deflected violently off the scale. Danger to the meter may be avoided to a considerable extent by first touching the segments about halfway between the brushes—for example, in the figure, segments 13 or 14, say segment 14. In tracing out the circuits, current flows from segment 7 through coils 7, 8 and 9 to segment 10. From segment 10 there are two paths for the current to get to segment 14. One of these is through coils 10, 11, 12 and 13, and the other is through part of coil 10 to the ground at X, through the core to the voltmeter lead at Y, then through the meter to segment 14 as indicated by the arrow heads. This is practically the same as connecting the meter to segments 10 and 14 and under this condition would have coils 10, 11, 12 and 13 connected between its terminals, consequently would have four times the voltage of one coil across its terminals, which would result in the needle being deflected off the scale.

If readings were taken from segments 13 and 12, it would be found that they would be less than that obtained from segment 14. When connected to bars 10 and 11, to which the grounded coil connects, a reading less than normal should be had. Consider the connection made to segment 11, as shown by the dotted line J' and neglect lead K. The flow of the current from segment 7 is through coils 7, 8, 9 to segment 10, whence there are two paths to segment 11. One of these is through part of coil 10 to the ground at X through the core to Y and through the meter to segment 11. The other circuit is through coil 10 to segment 11. From segment 11 the circuit continues through coils 11, 12, etc., to segment 19 and the negative side of the line. In this case it is seen that only part of coil 10 is connected between the voltmeter terminals, consequently the meter will give a lower indication than if the meter were connected to segments 10 and 11, under which condition all of coil 10 would be connected between the meter terminals. How low the reading of the meter will be, when connected to segment 11 and the core, will depend upon how much of the coil 10 is in the circuit. If the ground is near lead a the reading will

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be near normal, since this will amount to about the same thing as connecting lead *J* to segment 10 instead of to the core at *Y*. On the other hand, if the ground is near lead *b*, the reading will be low, since only a small portion of the coil is connected between the meter terminals

This will be better understood by referring to Fig. 4, which shows a single coil on a section of the core, which and a ground in the coil at *X*, the circuit is from segment 10 through the coil to *X* and to segment 11. From *X* there is a circuit through the core and meter to segment 11. From this it is seen that the voltmeter is connected to, what is equivalent to, *X* and segment 11, therefore, will read only the voltage between these two points. Since the length of conductor between *X*

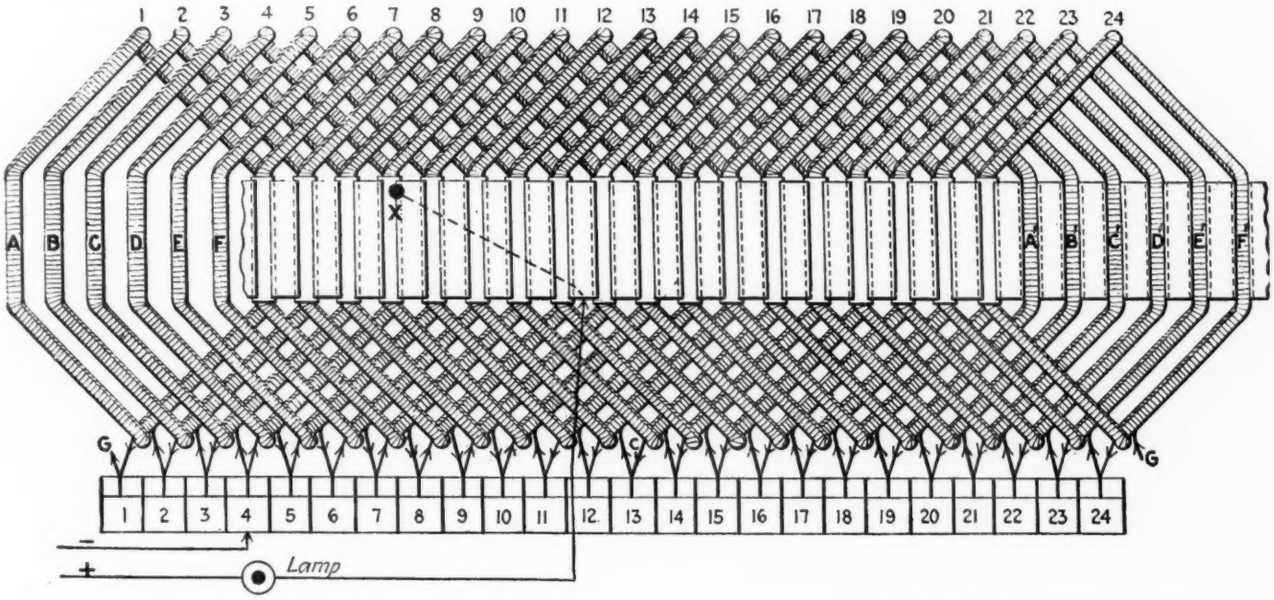


FIG. 2—SHOWS CIRCUITS THROUGH PARALLEL ARMATURE WINDING WHEN TESTING WITH A LAMP

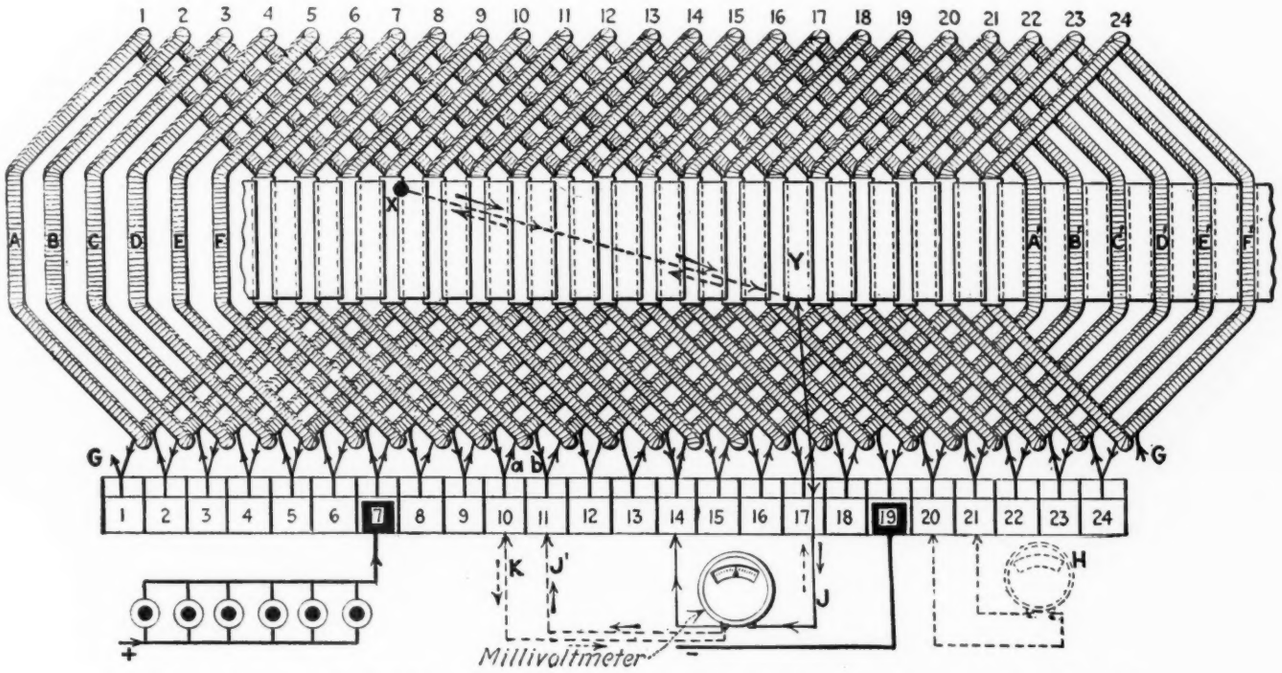


FIG. 3—TESTING PARALLEL ARMATURES FOR GROUNDS WITH LOW-READING VOLTMETER

we may assume to be coil 10, connected to segments 10 and 11. To make the explanation simple assume that one volt exists across segments 10 and 11 to cause the current to flow through the coil. Now if the voltmeter was connected to segments 10 and 11, it would read one volt, the voltage across the coil. With the voltmeter connected to segment 11 and the core as shown, and segment 11 is a small portion of the total coil, the volts between these two points will be only a small part of the whole, or in this case a small part of one volt.

Assume the ground to be at X_1, as in Fig. 5. Under this condition the voltmeter circuit is from segment 10 through a small section of the coil to X_1, then through the core and meter to segment 11. This is practically

the same as taking the meter lead off the core and connecting it to segment 10. Only a small part of the voltage between segments 10 and 11 is used up to cause the current to flow from 10 to X_1, therefore the remainder is effective across the meter terminals and will cause a deflection of the needle nearly equal to that obtained when connected to segments 10 and 11.

If the voltmeter lead is changed from segment 11 to 10, as indicated by K, Fig. 3, there will be two circuits for current to flow to coil 10. One of these is from segment 10 through coil 10 to segment 11. The other circuit is from segment 10 through the meter to the core at Y and through the core into the coil at X, then through part of the coil to segment 11. When the meter lead was on segment 11, the flow of the current through the instrument was into coil 10 to the core and to the meter, as indicated by the arrows shown in full line, but with the lead on segment 10 the flow of the current is from segment 10 through the meter to the core and coil, as indicated by the dotted arrows. Reversing the current through the meter will give a reverse deflection of the needle. This would be another indication of the ground.

Indications of the Grounded Coil

When the lead is changed from one segment to the other of the two, to which the grounded coil connects, a reverse deflection of the needle is obtained. By changing the leads from segment 10 to Y and from Y to 10, a forward deflection will be obtained. This deflection will also be low, but whether it will be lower than obtained on segment 11 will depend upon how close to segment 10 the fault in the coil 10 is. If it is nearer to segment 10 than to segment 11, then the reading from segment 10 will be lower than that obtained from segment 11. On the other hand, if the fault is nearer to segment 11, then the lower reading will be obtained from this segment.

The reversal of the current in the meter and the value of the meter readings will be better understood by

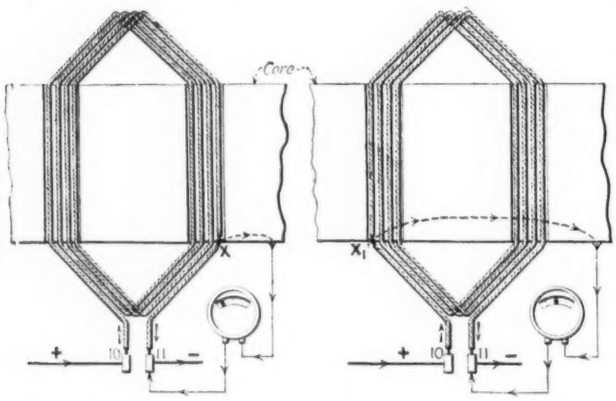


FIG. 4—LOW READING OBTAINED IF GROUND IS AT X

FIG. 5—HIGH READING OBTAINED IF GROUND IS AT X_1

referring to Figs. 6 and 7. With the grounds near segment 11, as in Fig. 6, the meter circuit is from segment 10 through the meter to the core, through the core and into the coil at X and to segment 11. In this case only a small part of the coil is in series with the meter, so that nearly the full voltage between the two segments is impressed on the meter. Taking the extreme of this and assuming the ground to be on segment 11, then the circuit would be from segment 10 through the instrument to the core, then through the core and shaft to segment 11 and the negative side of the line. If good connections to ground are made, then it will be about the same as if the meter were connected directly to segments 10 and 11 and the needle will be deflected accordingly.

On the other hand, if the fault were on the coil, as at X_1 in Fig. 7, the reading would be low. In this case the meter circuit is from segment 10 through the in-

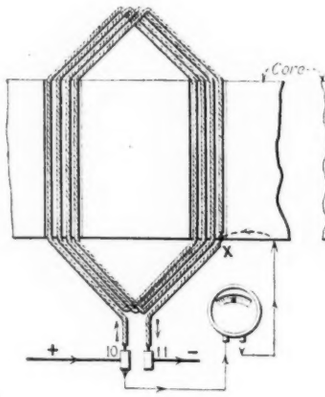


FIG. 6—HIGH READING OBTAINED IF GROUND IS AT X

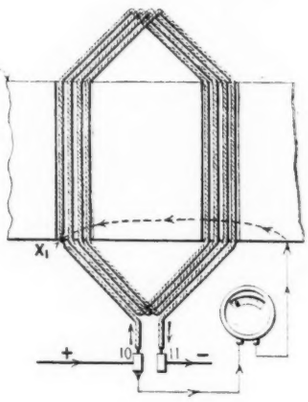


FIG. 7—LOW READING OBTAINED IF GROUND IS AT X_1

strument and to the core, then into coil 10 at X_1 through the coil to segment 11 and the negative side of the line. Under these conditions practically all of the coil is in series with the meter and the reading will be low. If the ground were on segment 10, this would be practically the same as connecting both meter leads to segment 10, consequently the reading would be zero. The farther the fault is away from segment 10 the higher the reading will be until segment 11 is reached, when a reading corresponding to the normal deflection is obtained between the segments. In comparing Figs. 4 and 5 with Figs. 6 and 7, the direction of the current through the meter is seen to be reversed, as explained in Fig. 3. In the first case the current in the meter circuit first flows into the coil and to the meter; in the latter it flows into the meter first and then into the coil.

Repairing the Grounded Coil

After the location of the defect on the commutator has been determined, the coil leads may be lifted from the two segments and with a test lamp the coil and segments tested for grounds. If the fault is in the coil, it will have to be taken out of the slots and reinsulated or replaced by a new coil. Of course, temporary repairs may be made by cutting the coil out of the winding and putting a jumper on the commutator in place of the coil. If two or more turns are grounded in the coil, it will be necessary to cut the coil in two to prevent heating if it is left in the winding. When the fault is in the commutator, it generally has to be opened up to clean the defect and make the repairs. Of course the readings obtained will be affected by the contact resistance of the ground, number of turns in the coil, etc. Although the problem in practice may not be quite so simple as indicated in the figures, they nevertheless show what may be expected.

The next article will treat of locating grounds in in series windings.

Holding the Piston Seal in a Gas Engine

By W. F. OSBORNE
Supervisor Manufacturers' Service, Texas Company

PISTON rings are put on a piston to help it hold the gases within the cylinder until their work is done. If a plain piston were used without rings, the unburned fuel mixture would leak past the piston on the compression stroke, wasting good fuel and lowering the maximum compression available. On the explosion stroke a part of the burned gases would leak past the piston and again power would be lost. Because of its length it is practically impossible to fit the entire piston tight enough to eliminate the leakage of gas, and even if it were feasible, the greater friction of the closely fitting piston would eat up the power saved.

Putting rings on the piston allows it to have a looser fit in the cylinder, thereby lowering its friction, without there being any loss of power. Rings that fit tightly against the cylinder walls will allow less gas leakage than loosely fitting rings, but their friction will be high. If the rings are too loose, they will not properly prevent gas leakage. The proper ring will balance up the question of power loss by leakage and the power loss by high ring friction.

There are all kinds of rings on the market; some are good, and some are not so good. A ring that works perfectly in one engine may be of no value whatever in another kind of engine. No ring can work properly in a cylinder that is worn out of round or that is larger at the end than in the middle.

When proper lubrication is not secured, the cylinder is likely to wear on the sides that carry the thrust due to the eccentricity of the crank, so that when rings are fitted, if they are just right for the diameter one way, they are too loose the other way. Flexible rings are likely to fit such cylinders a little better than stiff rings, although there is little chance that a perfect seal can be secured simply by the metallic contact of rings and cylinder.

Rings for Worn Cylinders

When there is a film of oil on the cylinder, if it is of the right thickness and the oil possesses the proper characteristics, the friction of the tight-fitting ring can be lessened and the seal of the loose fitting ring improved. Taking as an example, the vertical cylinder of a four-stroke-cycle engine, as the piston moves downward on the suction stroke, the lower edge of the ring scrapes a portion of the oil off the cylinder wall, forming a considerable body of oil on the advancing side of the ring. This oil "wave" reduces the passage of air into the cylinder past the rings, and allows the piston to draw in a full charge of the fuel mixture.

On the compression stroke the oil builds up on the top edge of the ring, and so prevents the blowing of the compressed vapor past the rings. As the piston is forced down on the explosion stroke, the pressure is exerted upon the oil resting on the top side of the ring. If there is only one ring, most of this oil will probably be blown out of the piston clearance space by the high-pressure gases, but when there are two or more rings, any oil blown away from the top ring, packs up against the second ring and tends to prevent the further passage of the gas.

Another place for gas leakage is through the clearance space back of the rings, between the ring and its groove. If the ring is a loose fit in the groove particularly with respect to width, the vapor will find its way around the ring and power will be lost. The oil is of benefit here too, as it fills this clearance space, and its resistance helps to prevent the gas leakage. The value of the oil in assisting the rings is particularly noticeable where the cylinder is not perfectly round, so that it is impossible for the rings to prevent leakage of gases without the assistance of the oil.

Effect of Viscosity

The physical properties of the oil that influence its seal-forming value are viscosity, surface tension with respect to metal, and cohesion. There may also be some chemical reaction between certain constituents of some kinds of oils and the metal of the cylinder and the piston which increases its adhesion to the metal and prevents the oil from being scraped off.

Other things being equal, we would expect that a high viscosity would cause the oil to offer a greater resistance to being blown out of the clearance space and would also permit the accumulation of a larger body of oil on the advancing side of the rings than could be secured by a lower-viscosity oil. We find by actual experience that the piston seal can be greatly improved in many instances by raising the viscosity of the oil; better compression is secured and more power developed by the engine at a lower consumption of fuel per horsepower. This is especially true where the piston, cylinder and rings have become worn.

From this statement we might reach the conclusion that if a high-viscosity oil is good, a higher viscosity would be better. This is not true, as we sometimes find that if the viscosity is too high the oil will not work its way between the piston and the cylinder fast enough, the cylinder becomes dry, and many troubles follow the lack of sufficient oil.

Choice of Oils

Should the viscosity be a little low, there is not likely to be lack of lubrication, but simply loss of power through gas leakage and troubles from excessive oil in the cylinder and carbon deposits with fouled ignition points. So we must get just the right viscosity, and since the viscosity varies with the temperature, we must have the right viscosity at the working temperature of the oil film. Some engines run hotter than others and need a heavy oil. Others run cool and a viscous oil could not feed fast enough to give proper lubrication.

An oil with a low surface tension with respect to the metals of which the cylinder and piston are composed, will adhere more tightly to them than an oil with a higher surface tension; in other words, its adhesiveness will be greater. A high adhesive quality will also prevent the oil from being blown off the cylinder wall and out of the clearance space and therefore will improve the piston seal. Unfortunately, it is a difficult matter at present to measure the adhesion of oils with respect to different metals, and we have to depend entirely upon actual running tests to determine the value of the various lubricants.

Commercial Economy of High Pressures and Temperatures

IT is the opinion of Mr. Orrok that steam plants of 1,200-lb., and 750 deg. F. total temperature, are justified as coming commercial developments. Physical conditions and thermodynamic considerations favor increasing pressures. Higher temperatures are attainable, but are not so conducive to economy. Other changes may produce savings equal to those proposed in prime-mover conditions.

THE future steam plant as demonstrated by facts, theory and calculations, is ably discussed by George A. Orrok, consulting engineer of the New York Edison Co., in a paper to be presented at the December meeting of the A.S.M.E. in New York. His conclusions indicate that:

Economy will be inevitably increased; history and present requirements show no reasons to the contrary. Increasing temperatures and pressures, changing the steam cycle, and improving the general efficiency are points to be considered.

Temperature may be considerably increased, if warranted. The limit, however, is comparatively near; practical difficulties, which endanger reliability, are looked upon as a menace at the present time. A review of conditions, however, indicates that 1,100 deg. F. should be attainable when our materials are improved.

Pressure increase involves redesign of no great difficulty and represents one of the most convenient methods; 1,200 — 1,500 lb. may be produced.

The steam cycle is being improved by application of the regenerative heater arrangement as far as practical; thermodynamic considerations reveal that this cycle may be applied with appreciable advantage to increased pressures, but only a comparatively insignificant gain would result from increased temperature.

Improving plant operation and arrangement so as to meet the lowest limits of heat losses that are known to be possible, might produce a gain equal to that of a combined regenerative cycle with increased temperature and pressure.

Improve from 0.82 to 19 Per Cent Thermal Efficiency in 152 Years

The earlier use of steam before its expansive force had been discovered, is best shown by the Newcomen pumping installations, where the steam was used at atmospheric pressure. Watt discovered the expansive force of steam and so improved the boiler, engine and steam piping, that 15 lb. gage could be used economically. From his time until about 1900 rising pressure kept pace with improvements in materials and in the design and construction of steam generators and piping, with occasional excursions into the higher realms of pressure and temperature. Practice at that date (1900) may best be illustrated by the work of the Wildwood engine. Since 1900 improvements in steam generators, piping and prime movers have been made with increasing rapidity, and many modern plants are running on 250 lb. and 200 deg. of superheat, using standard piping and valves with the newer designs of boilers, superheaters and turbines. Table I shows the pressure and economies possible and actually attained in a central station with all the results reduced to B.t.u. in the coal per kilowatt-hour of useful work.

Our engineers are now using better and more uniform materials than ever before. Our metallurgical and manufacturing methods have been greatly improved. Copper, wrought iron and cast iron have been discarded for boiler purposes. Steel and even alloy steels are in common use and their uniformity leaves little to be desired. Certain of the non-ferrous alloys are in common use and play their part in aiding the common security which characterizes modern installations. Copper boilers and 212 deg. maximum temperature gave place to wrought-iron boilers and 30 to 40 lb. pressure with a maximum temperature of 300 deg. The use of steel as a boiler material raised the pressure to 200 lb. and the temperature to 400 deg., while our modern steels allow pressures to 400 lb. with a maximum temperature of 750 deg. In certain distillation plants temperatures as high as 1,100 deg. have been obtained, but the life of the material is short.

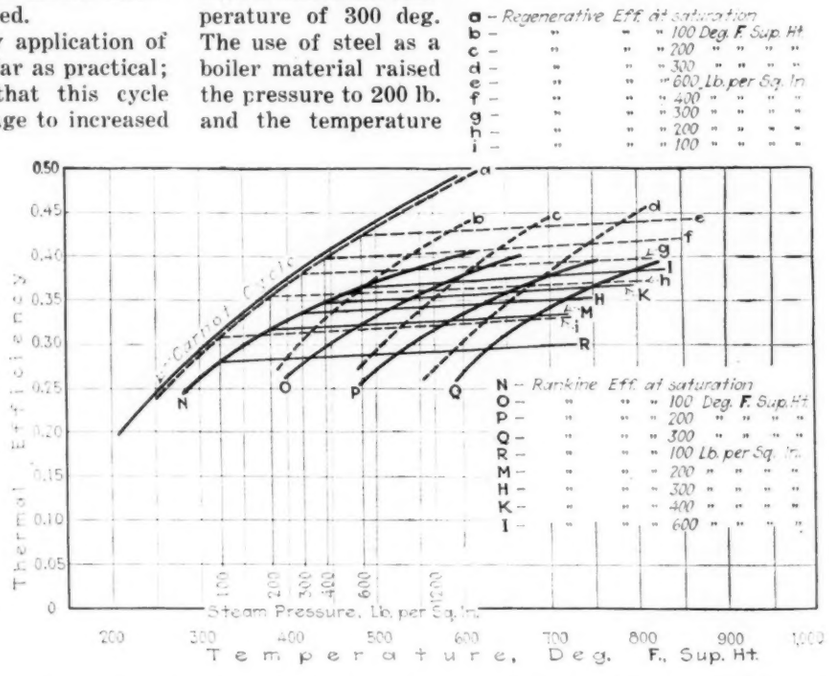

a – Regenerative Eff. at saturation
b – " " " 100 Deg. F. Sup. Ht
c – " " " 200 " " " "
d – " " " 300 " " " "
e – " " " 600 Lb. per Sq. In.
f – " " " 400 " " " "
g – " " " 300 " " " "
h – " " " 200 " " " "
i – " " " 100 " " " "
Carnot Cycle
N – Rankine Eff. at saturation
O – " " " 100 Deg. F. Sup. Ht
P – " " " 200 " " " "
Q – " " " 300 " " " "
R – " " " 100 Lb. per Sq. In.
M – " " " 200 " " " "
H – " " " 300 " " " "
K – " " " 400 " " " "
I – " " " 600 " " " "
Efficiency
Steam Pressure, Lb. per Sq. In.
Temperature, Deg. F., Sup. Ht.

FIG. 1—REGENERATIVE AND CARNOT CYCLE EFFICIENCIES PLOTTED TO PRESSURES AND ALSO TO SUPERHEATS

Efficiencies plotted to pressures are: Rankine, *N*, *O*, *P* and *Q* and regenerative, *a*, *b*, *c* and *d*. Note that these are curves. Efficiencies plotted to superheats are: Rankine, *R*, *M*, *H*, *K* and *I*; and regenerative, *e*, *f*, *g*, *h* and *i*. These are straight lines, practically parallel, showing that the gain due to increasing superheat is constant for equal increases of superheat.

Now it is well known that steel, when heated to comparatively low temperatures, say 900 to 1,000 deg., loses its strength and becomes unfit to sustain loads, and the heat strains from even moderate heating of 300 or 400 deg. may cause certain deformations of a highly unsatisfactory character. Cast-steel valves have deformed at 750 deg. to such an extent as to render them useless, and the "growth" of ordinary cast iron

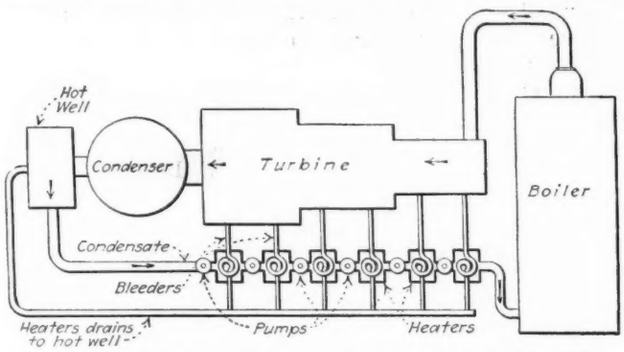


FIG. 2—HIGH THERMAL EFFICIENCY OBTAINED BY RAISING PRESSURE AND TEMPERATURE OF CONDENSATE IN STEPS

A number of surface heaters use steam bled from the turbine at various pressures during the progress of expansion. Pumps raise condensate pressure at each heater. Four or five heaters are now being used while better applications are being worked out.

at temperatures above 450 deg. is known to be destructive, but notwithstanding this the later constructions at 250-300 lb. pressure and 700 deg. maximum temperatures are commercial. The first cost is not excessive, repairs are moderate, and the life of the installation is all that can be desired.

Thermal Efficiency of 48½ Per Cent May Be Attained by Regenerative Cycle Using Steam at 1,200 Lb., 750 Deg. F.

The theoretical thermal efficiencies of the Carnot, the Rankine and a regenerative cycle using both saturated and superheat values for ranges up to 1,200 lb. and superheats of 750 deg. and above, have been calculated and plotted in Fig. 1. It will be seen that

TABLE I—POSSIBLE PRESSURES AND ECONOMIES

Year		Pressure Abs. Lb.	Temp.	Practically Possible Overall Thermal Efficiency	Actual B.t.u. Per Kw.-Hr.	Actual Overall Thermal Efficiency, per Cent
1770	Newcomen	15	212	2.7	416,000	0.82
1810	Watt	30	300	9.17	61,000	5.6
1900	Wildwood	215	400	20.8	19,200	17.76
1922	Modern	265	650	35.00	18,000	19.00

the chosen regenerative cycle for saturation follows very closely the efficiency of the Carnot cycle, while the Rankine cycle falls below the Carnot increasingly with rise of pressures. The superheat lines *b*, *c* and *d*, *N*, *O*, *P* and *Q*, for both cycles are nearly parallel and maintain this characteristic over a wide range. Gain from regeneration increases with pressure, as the curves mentioned rise with pressure, and is constant for equal superheat. For any final temperature the gain from pressure increments decreases, but the gain from regeneration increases with pressure increments. Thus at 750 deg. final temperature the Rankine efficiency increases from 33.5 per cent to 40.5 per cent with pressure rise from 200 to 1,200 lb., while the regenerative efficiency increases from 37 per cent to 48.5 per cent with the same pressure increase.

[The regenerative cycle used was discussed by Stanwood in 1899. This consists in extracting a small quantity of heat from each of an infinite number of points along the turbine casing, to be used in heating the condensate in steps to boiler temperature. The pressure must be raised a small amount between bleeding points so that boiler pressure and temperature are reached at the high-pressure end.

Fig. 2 illustrates such a system as described in *Power*, Dec. 6, 1921. Four or five heater stages are at present the nearest practical approach to the complete cycle, this explanation being added to Mr. Orrok's paper for the benefit of those unfamiliar with this arrangement. —Editor.]

Fig. 1, being theoretical efficiency, does not show the station losses, aggregating around 45 per cent. Grouping the losses, we may say that the generator efficiency is 97 per cent, turbine efficiency 78 per cent, boiler efficiency 80 per cent, leaving for piping, auxiliaries and radiation 91 per cent, which multiplies up to 55 per cent efficiency.

Table II shows how these figures work out for the foregoing suppositions.

TABLE II—COMPARING B.T.U. PER KW.-HR. WITH RANKINE AND REGENERATIVE CYCLES

Case	Cycle	Pres., Lb.	Max. Temp.	Theoretical Effi.	Station Effi.	Actual Effi.	B.t.u. per Kw.-Hr.
1	Rankine	200	750	33.5	55	18.4	18,500
2	.....	1,200	750	40.5	55	22.3	15,300
	Gain	.....	.....	21%	.....	.....	3,200
3	Regenerative	200	750	37	55	20.35	16,800
4	.....	1,200	750	48.5	55	26.7	12,800
	Gain	.....	.....	33.3%	.....	.....	4,000

The saving by regeneration Case 1 minus Case 3 is 1,700 B.t.u. and in Case 2 minus Case 4 is 2,500 B.t.u. Considering the trend of the curves in Fig. 1, compar-

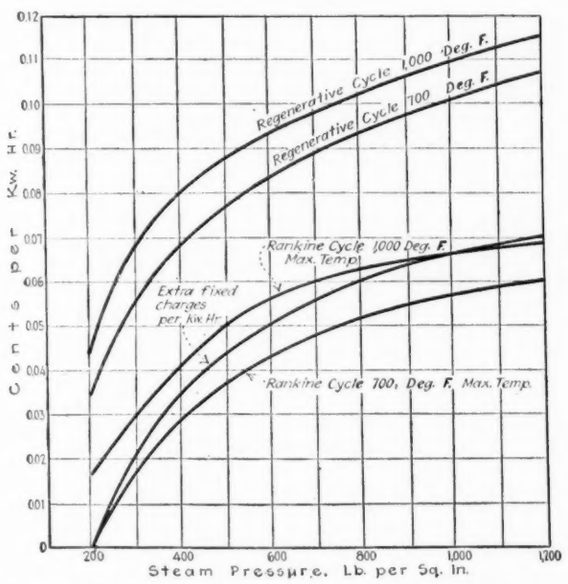


FIG. 3—SAVINGS IN CENTS PER KILOWATT-HOUR BASED ON COAL AT SIX DOLLARS PER TON

Extra fixed charges are greater than coal saving for Rankine cycle at maximum temperature of 700 deg., plotted to steam pressure.

atively little is gained by further superheating, but there has been no attempt to go above 800 deg. and the flattening out is much more marked as the temperature increases.

Physical Conditions

Water has a critical temperature of 704 deg. and the critical pressure is about 3,200 lb. Pressures up to this limit may therefore be considered, and since oil still

temperatures up to 1,100 deg. have been used, we may consider superheat temperatures up to that point. We know that the first allotropic change in steel occurs at about 1,300 deg., and 1,100 deg. is well below this point. Here, however, we must look into the physical properties of the steels used in power-plant construction.

When steel is heated, the first sign of change, a dull red just visible in the dark, appears at about 750 deg.

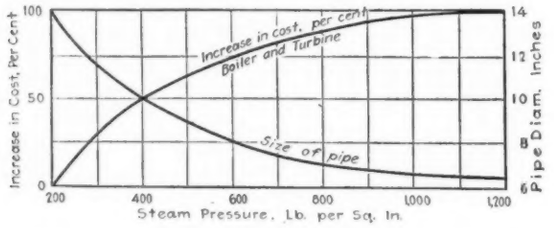


FIG. 4—INCREASING PRESSURES TO 1,200 LB. DOUBLES COST

Visibility in daylight begins at about 850 deg. to 900 deg., and a full dark red is attained at about 1,100 deg. The full cherry red is attained at the first allotropic change of 1,300 deg. Good boiler steels increase in tensile strength up to about 600 to 700 deg. and lose much in ductility, but above 800 deg. the tensile strength rapidly falls off and the ductility largely increases. Cast steels of proper carbon content suitable for fittings, valves and turbine construction show the same properties within rather narrow limits. Pipe steels have nearly the same characteristics, but the temperature at which the tensile strength starts to fall is around 550 deg. to 600 deg. This lack of ductility or increase of brittleness at the maximum temperature of use must be compensated for by a larger factor of safety (that is, increased thickness and weight) with higher cost and a more careful selection of material.

TABLE III—SAVINGS IN COAL

Pressure	Superheat Temp.	Carnot Eff.	Reg. Eff.	Rank Eff.	Reg. × 0.55	Rank × 0.55	Reg. B.t.u.	Rank B.t.u.	Saving over Regenerative 200 Lb., 700 Deg. B.t.u. per Kw. Reg. C	Saving over Regenerative 200 Lb., 700 Deg. B.t.u. per Kw. Rank C	Saving Lb. Coal per Kw.-Hr. 13,800 B.t.u. Reg. C	Saving Lb. Coal per Kw.-Hr. 13,800 B.t.u. Rank C
200	700	53.5	37	33.4	20.3	18.35	16,820	18,620	1,800	.....	0.13	.....
400	700	53.5	41.2	36.3	22.6	19.95	15,100	17,120	3,520	1,500	0.255	0.109
600	700	53.5	43.5	38	23.9	20.9	14,300	16,350	4,320	2,270	0.313	0.164
1,200	700	53.5	47.5	40	26.1	22	13,100	15,500	5,520	3,120	0.40	0.226
200	1,000	63	38	35	20.9	19.25	16,350	17,750	2,270	870	0.165	0.063
400	1,000	63	42.8	37.6	23.5	20.7	14,500	16,500	4,120	2,120	0.299	0.153
600	1,000	63	45	39.5	24.7	21.7	13,820	15,720	4,800	2,900	0.348	0.21
1,200	1,000	63	49	41.5	26.9	22.8	12,700	14,970	5,920	3,650	0.43	0.265

But with increased thickness it must not be forgotten that the safe stresses must be correspondingly lowered.

This subject may be considered from five points of view depending on the conditions under which the materials are to be used.

A. *Boiler Material*—Here we know that the maximum temperature cannot exceed 704 deg., since water is a gas at all higher temperatures, and the fire side of the tube can be only a few degrees hotter. If 1,200 to 1,600 lb. per sq.in. be the chosen pressure, the water temperature is 625 deg. at maximum and the fire side will not exceed 725 deg. normally. This temperature is well within the maximum strength zone and only care is needed to secure sufficient ductility.

B. *Superheater Material*—The maximum temperature of the inner surface of the tubes may be a little higher than the maximum superheat. The outer temperature depends on the position in the boiler. Radiant-heat superheaters are now commercial where the pressure parts are protected with a heat absorbing and conducting covering of cast iron. The fire surfaces may be 1,400 to 1,600 deg. F., while the inner wall temperature is as low as 700 deg., but 1,100 deg. is comparably easy of attainment. Bare tube superheaters would have a maximum outside temperature of around 1,200 deg., but the life at this temperature is unknown. The maximum safe point may be taken as 800 deg. steam temperature and 950 deg. outside temperature.

Neither the tube manufacturers nor superheater manufacturers are afraid of these conditions, and I believe they are prepared to guarantee their product under such conditions.

C. *Piping Material*—Under this category the condition is markedly different. The steam side of the pipe wall is below the maximum temperature of the steam. The outer surface is much lower and the thickness of the material can be increased to compensate for the lower elastic limit of the material. The ductility is improving with temperature increase. Pipe joints are the only serious trouble, and the modified Van Stone joint with the pipe edges welded for tightness is the apparent solution. Experience with this joint has been satisfactory.

D. *Valves and Fittings*—Valves and fittings must necessarily be made of castings, and the low-carbon open-hearth steel used, while falling off in strength sooner than the worked material used in boiler and piping, has still a respectable elastic limit at 1,100 deg. As in the last category, the inside wall temperature is lower than the steam temperature with still lower temperatures at the outer wall. But the shape of the casting is all important. Globe valves of the double beat or Wanick type can be made with practically no flat surfaces and with two axes of symmetry. Internal pressures do not seriously deform this design, but external strains may cause minor troubles. Throttle valves and marine stop valves are usually of this type and can be kept tight at 750 deg. F. It is probable that temperatures of 1,100 deg. could be safely undertaken with these valves if special precautions were used in the design of the seat, disk and stem. The flexible disk, double-beat valves are used in Europe at temperatures in excess of 750 deg.

Gate valves have only one axis of symmetry and flat surfaces of considerable size. Here seat and disk troubles are encountered at temperatures above 700 deg., and it may be some time before the manufacturers can guarantee a tight job at the higher temperatures. This type of valve is peculiarly sensitive to outside strains tending to deform the seats and disk.

E. *Turbine High Pressure Ends*—Pressures can make little difference here as the high-pressure parts are comparatively small and without doubt the pressure will be reduced 50 per cent in the first nozzle. There need be no high-pressure stuffing box so that the highest pressure to be packed against will be about half the maximum. Temperature strains will be the only thing that need be considered, and the expansion will reduce the temperature in the first stage nozzle to a workable value, which is 750 to 850 deg. It is to be noted that

steam-chest or nozzle-box troubles have been the only prominent troubles where 400 lb. and 750 deg. total temperature have been tried out, and it thus appears that a proper design will obviate most of the trouble. Cast or forged steel must be the material used for all parts subjected to high temperatures.

In general the turbine designers say that 1,200 to 1,500 lb. pressure has no terrors and can be used when desired. They can supply the apparatus. Temperatures are more troublesome and no one apparently cares to go much above 700 to 750 deg. at the present time. Superheater and valve materials at present seem to be the deciding factor in the use of high pressures and temperatures, and there is apparently very little that careful design and the selection of proper materials will not overcome.

Cost of Increasing Pressures and Temperatures

Only a portion of the central-station installation is affected by high pressures and temperatures, especially where electric auxiliaries are used. The boiler and piping system and prime mover cover the entire list, and in the usual central station this represented about 40 per cent of the entire installation cost. Latterly, with the larger stations the percentage is around 30 and may be taken at 25 per cent for the newer and larger stations, of which Hell Gate and Calumet are types. If the station cost be taken at $100 per kw., an average figure, this portion of the installation has cost $25 and at 15 per cent the fixed charges are $3.75 per year, or on 5,000 hours' use 0.07 cents per kw.-hr. What, then, will be the extra cost of this apparatus when designed for higher pressures and temperatures? Standard boilers today can be bought up to 275 lb. pressure; 300 lb. necessitates thicker plates and tubes and prices advance accordingly; 400-lb. boilers have been purchased recently, and 500-lb. boilers have been built. Flash boilers of the Serpolett and Delaval types using pressures in excess of 1,200 lb. and coil boilers of the Herreshoff type using equally high pressures, have been built as experiments or in toy sizes as for automobile work or for high-speed launches. Schmidt's water-tube boiler working at 900 lb. has been run 14,000 hours with marked success. Boilers for 400 lb. pressure have been offered at about 50 per cent increase in price, and 1,200-lb. boilers have been figured at a 100 per cent increase in price.

Conclusions

Turbine designers are at work on designs arranged to utilize higher pressures, but higher temperatures seem more troublesome to them. I have no estimate, but we can safely apply the same percentage increases of price to the turbine that obtained with the boiler. Steam piping decreases in size with increasing pressure, so much so that it is doubtful if a 1,200-lb. steam line would cost more than a 200-lb. line of the same capacity. The volume of high pressure steam at 1,100 deg. maximum temperature is quite uncertain, but the chances are that our figures are not more than 10 per cent from the truth.

We may then summarize as follows:

A. Pressures up to 1,200-1,500 lb. at least are commercial and may be attained without serious difficulty.

B. Temperatures for the present are commercial up to 700-750 deg., which should not be exceeded until our materials for valves and superheaters are improved. More extended experience is necessary before the range of 800 deg. and over is attempted in a commercial installation.

C. With the completion of the steam table research it will be possible to calculate accurately just where the possible limits of economy in pressure and temperatures may be located. At the present time the uncertainty of all values above 200 lb. pressure and 400 deg. F. temperature render most of our calculations of only academic value.

D. There still appears to be more economy in a closer study of operation and construction losses resulting in improving the efficiency of central stations installed in accordance with the present accepted canons of design than in the attempt to increase widely the temperature range of our heat cycles. While we may save 4,000 B.t.u. per kw.-hr. by using a regenerative cycle and increasing pressure and temperature, it should be possible to save nearly as much by a reduction to the lowest limits of the heat losses which we know exist in our present installations.

In Table III there are given for 700 and 1,000 deg. maximum temperature and for four pressures the theoretical efficiencies of the three cycles used, the practical efficiency of the Rankine and regenerative cycles and the savings per kilowatt-hour for all conditions over the Rankine cycle at 200 lb. and 700 deg. maximum temperature in B.t.u. and pounds of coal of 13,800 B.t.u. content.

In Fig. 3 are plotted these savings in cents per kilowatt-hour on the basis of $6 coal, together with the extra fixed-charge curve. Fig. 4 shows the percentage increase of boiler and turbine and the decrease in size of pipe required for a given quantity of steam. It will be seen that the extra fixed charges are always greater than the coal saving for the Rankine cycle (ordinary operation) at 700 deg. maximum temperature and the additional gain for the 1,000 deg. maximum temperature barely exceeds the additional fixed charges. *We cannot then expect much from increasing pressures and the ordinary methods of using steam. Increasing temperatures help to some extent, but not enough to be attractive since the saving is nearly all used up by the additional fixed charges.*

With the regenerative cycle the results are much better and useful savings are indicated, increasing considerably with pressure and slightly with temperature. It is evident that some such regenerative cycle must be used, but the rewards from increasing temperature are not commensurate with the costs. Many regenerative cycles are possible, but the one used shows nearly the maximum economy. Such cycles need many heat interchangers and a number of separate feed pumps for the close approach to theoretical figures. Indeed, Stanwood in 1899 pointed out that with an infinity of heaters and pumps the Carnot efficiency might be equaled. So far, however, four or five stages have been the ultimate practical application and not more than three have stood the commercial test. It would appear that better design must be put into the apparatus if many steps are proposed, and also more consideration must be given to the operating difficulties.

Mr. Orrok makes acknowledgment to W. S. Morrison, M. A. Guigou and H. H. Worth for much of the work in connection with the preparation of the paper. Mr. Morrison prepared an appendix (not given here) on the variation of the strength of materials with temperatures, Mr. Guigou made most of the calculations, while Mr. Worth prepared the diagrams.

The Diesel Engine and How It Operates

ANYONE familiar with the operation of an automobile engine should easily grasp the cycle of events occurring in the cylinder of the Diesel engine.

THE features which set the true Diesel apart from other oil engines are: (a) Compression sufficient to produce auto-ignition of the fuel; (b) injection of the fuel by an air blast; (c) combustion with practically no change in pressure from the maximum compression pressure.

Fig. 1 *A* to *D* show the valve action and the conditions existing in the engine cylinder when the piston is at different points in the engine cycle. The pressure in the cylinder at any point in the piston stroke is indicated in Fig. 1 *F* while Fig. 1 *E* shows that part of the crank circle swept by the crank during any of the several events in the engine cycle.

Fig. 1 *A* covers the suction, or admission stroke of the piston. The admission, or air-suction, valve at *J* has opened at the point *a* just before the piston has reached upper dead center. This valve remains open from the point *a* to the point *b* during which time the piston moves downward, drawing in a cylinder charge of air, reverses and starts to move upward. This does not mean that the piston pushes part of the air charge back out through the admission valve. In operation the rush of the air through the air valve continues even after the piston starts upward. The momentum of the air causes it to "pile up" in the cylinder; in this way the amount of air entering the cylinder is actually greater than if the valve had closed at bottom dead center. This admission stroke is shown in Figs. 1 *E* and *F*; in the latter the indicator diagram shows this line as being slightly below the atmospheric pressure line *xy*. In Fig. 1 *B* the admission valve *J* has closed at *b* and the pure air charge is compressed by the piston up to the point *g*, which is top dead center. This process is covered by the compression line *bc* on the indicator diagram in Fig. 1 *F*. The clearance volume is very small, and the maximum or final compression pressure rises to some 450 to 550 lb. per sq.in. The work done on the air charge in compression causes the temperature to rise to a final temperature of 900 to 1,400 deg. F., the air being in a red-hot condition.

At the point *c* in Fig. 1 *C* the injection valve *K* opens, and a charge of fuel is blown into the cylinder by means of a blast of high-pressure air. The fuel-injection valve or spray valve, as it is often called, is designed to cause the rate of flow through the valve to be regulated so that the entire oil charge is not injected instantaneously, but takes place while the engine crank turns through a considerable angle. In Fig. 1 *C* the injection of fuel starts when the crank is at *c* and ends when the crank is at *d*. In Fig. 1 *F* the line *cd* represents the fuel admission and combustion period, and the desired condition is attained when the line *cd* is practically horizontal, showing that the rate of heat addition is such that there is no increase in the cylinder pressure.

The injection and the combustion of the fuel ceasing at the point *d*, the piston continues to the end of its stroke under the influence of the expanding gases. Before the completion of the stroke the exhaust valve *L* opens when the crank is at *e*. This allows the gases to rush out through the exhaust passage. The exhaust valve continues to remain open until the piston again ascends to the top of the cylinder, expelling all the exhaust gases. This part of the cycle is shown in Figs. 1 *E* and 1 *D* as continuing from *e* to *f*. In Fig. 1 *F* this forms the exhaust *ef*. Before the exhaust valve *L* closes, the admission valve opens at *a*, allowing a fresh air charge to be inducted into the cylinder during the stroke shown in Fig. 1 *A*.

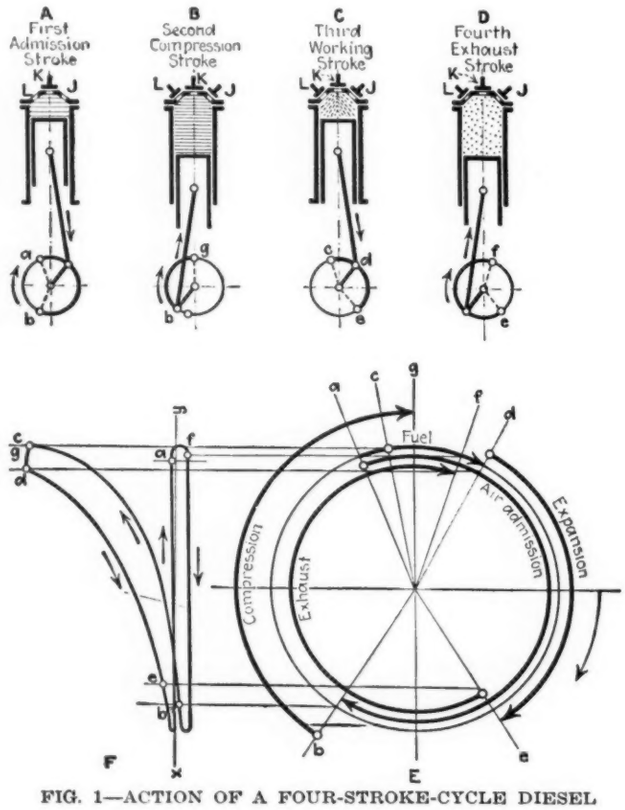


FIG. 1—ACTION OF A FOUR-STROKE-CYCLE DIESEL

These events complete the cycle of the four-stroke-cycle Diesel. From a practical viewpoint the differences between the Diesel and the gas engine are that in the Diesel nothing but pure air is compressed in the cylinder and that the fuel is forced into the cylinder slowly, causing the combustion to be gradual; in the gas engine both the gaseous fuel and the air are compressed and the combustion takes the form of an explosion.

Summarizing, the Diesel four-stroke-cycle consists of (1) a suction stroke during which a charge of pure air is drawn into the cylinder; (2) a compression stroke wherein this air is compressed by the piston to a maximum pressure; (3)

a period of injection and combustion of a charge of fuel and the expansion of the gases, this being the working stroke of the piston, and (4) an exhaust stroke by means of which the burnt gases are expelled from the cylinder.

The air charge should be drawn into the cylinder at atmospheric pressure (zero gage, or 14.7 lb. absolute). Since the only reason air or any gas flows from one point to another is a difference in pressure, it follows that the pressure in the cylinder must be somewhat below that of the atmosphere if the air charge is to flow in and fill the cylinder. If there is a direct passage into the cylinder, this difference in pressure need be but a few ounces. Where a long air suction line is used, such as installations with the air line leading from outside the building, the drop may easily reach 2 lb. This would give a pressure at the beginning of compression of 12.7 lb. in place of 14.7 lb.

The purpose of the compression in any internal-combustion engine is to raise the pressure and the temperature of the air charge, or in case of a gas or gasoline engine the mixture of gas and air. It has been found that the efficiency depends upon the compression ratio and the temperature at the beginning and end of the compression stroke.

The compression pressure in the Diesel engine depends upon (1) the attainment of a satisfactory efficiency; (2) the securing of a temperature sufficient to produce self-ignition of the fuel and air charge, and (3) the mechanical construction of the machine.

Experience has demonstrated that the increase in thermal efficiency by increase of compression pressure above 500 lb. per sq.in. is too small to overcome the disadvantages from constructional and operating view-

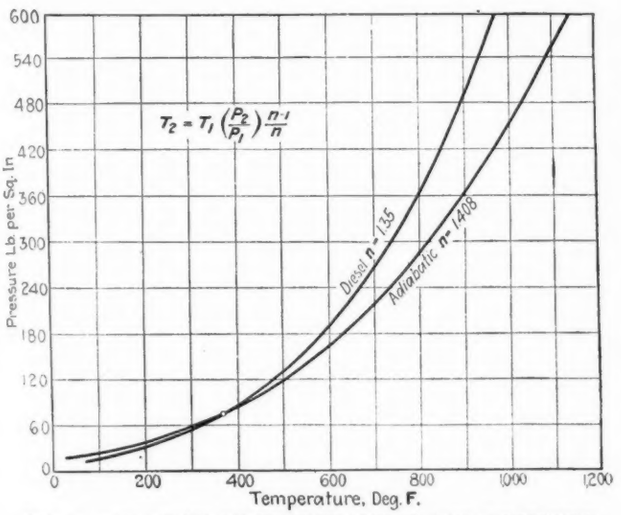


FIG. 2—RELATION OF TEMPERATURE AND PRESSURE IN AN ENGINE

points. It is customary to carry a maximum compression of 480 to 520 lb., although in certain high-speed and two-stroke-cycle engines pressures up to 600 lb. are not unusual. Since the compression temperature must be above the ignition point of the fuel, there is a minimum pressure possible to employ in the true Diesel.

The temperature of the air charge at the end of the compression stroke must be high enough to ignite the fuel. If no heat was lost to the cylinder walls—that is, if compression was adiabatic—the relation of the pressures and temperature at the beginning and the end of the compression stroke would be expressed by the equation,

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

in which

T_1 = Temperature at the beginning of compression in deg. absolute (460+ F. reading);
T_2 = Final compression temperature;
P_2 = Final compression pressure, lb. absolute;
P_1 = Initial pressure;
n = 1.408.

This relation is shown in Fig. 2 by the curve marked adiabatic. There is a loss of heat during compression

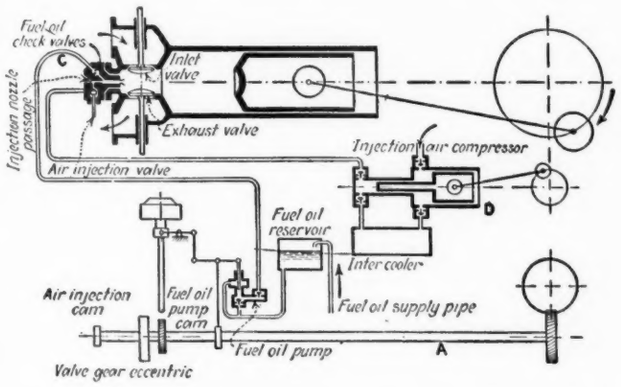


FIG. 3—SCHEMATIC ARRANGEMENT OF A DIESEL ENGINE

and expansion. By reason of this compression is not adiabatic, but is fairly represented by the expression with the value of n of 1.35. This relation is shown by the second curve in Fig. 2.

The fuel valve closes after the piston has traveled about 10 per cent of its stroke, the crank moving about 40 deg. of its cycle. The fuel and air mixture theoretically should be completely burnt by the end of the fuel injection, but in the actual engine the combustion continues far down the expansion line.

While the Diesel is spoken of as a constant-pressure engine—that is, the heat is added at constant pressure—it is seldom that an indicator diagram from an engine in every-day service shows a horizontal combustion line. A sloping line is customary and has been found to give a higher efficiency. With the ideal horizontal combustion line, while the pressure is constant, the temperature rises from a final compression temperature of, say, 1,200 deg. to some 2,700 to 3,500 deg. F.

At the beginning of this fuel-combustion period the opening of the fuel valve is followed by a slight time lag before the fuel enters the cylinder and ignites. This lag is due to the inertia of the fuel resting in the fuel valve, to the resistance of the atomizer disks, and to the slowness of ignition after the oil is in the cylinder. This delay in ignition depends upon the compression pressure and temperature and upon the pressure of the air spray.

In the actual engine the exhaust valve opens before the end of the stroke, approximately 50 deg. ahead of crank dead center, or about 10 per cent of the stroke. The energy lost by early release is negligible, and if the release is delayed until dead center, the drop in pressure will be carried on during the part of the exhaust stroke, making the negative work of the exhaust stroke greater.

The temperature of the gases, when first issuing through the exhaust valve, is around 1,000 deg. F. This temperature does not exist beyond the valve since the pressure drop is accompanied by a temperature drop. The exhaust temperature will range from 400 to 750 deg. F.

The return stroke of the piston forces these exhaust gases out through the exhaust line, the gas temperature

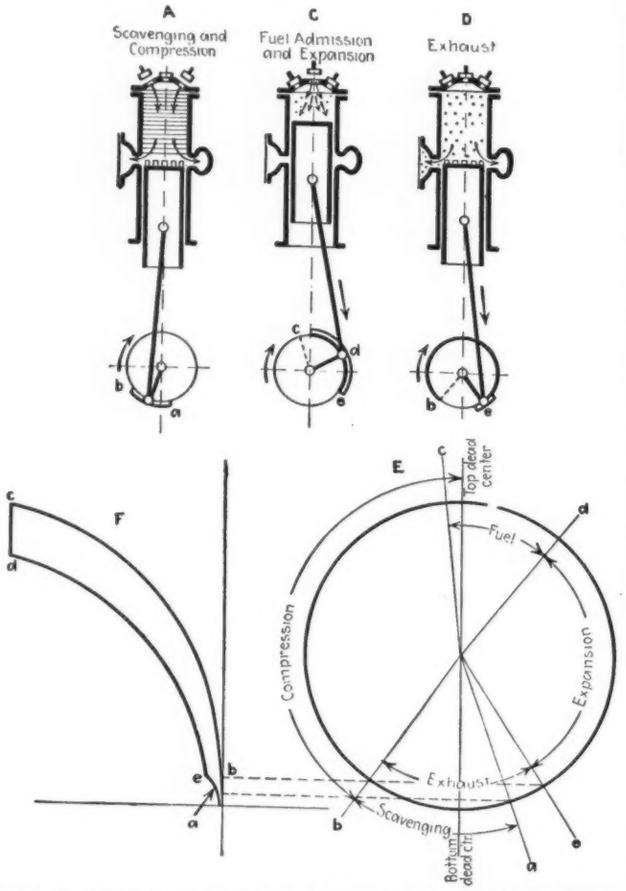


FIG. 4—CYLINDER EVENTS OF THE TWO-STROKE-CYCLE DIESEL

falling considerably during this stroke. There is, however, the clearance volume, which is filled with burnt gases when the piston reaches the ends of its stroke. To remove this volume of inert gas, it is customary to allow the exhaust valve to remain open somewhat after the piston completes this stroke, reverses, and starts on the suction stroke. The admission valve is open ahead of dead center, and the momentum of the column of exhaust gases causes the flow to continue even after the reversal of the piston, creating a partial vacuum into which the fresh air rushes.

Fig. 3 embodies the schematic arrangement of the essential mechanism of a Diesel engine. In this particular instance the engine is of the horizontal type operating on the four-stroke-cycle principle. The engine crank is represented with its center at *O*, and the crank revolves clockwise. To the crankshaft is geared a layshaft *A* which revolves at half engine speed. On this layshaft are mounted the cams used to actuate the exhaust, admission and fuel-injection valves, which are operated in the sequence outlined in Fig. 1. The fuel pump is driven off the layshaft *A*, the amount of fuel charge being under control of the governor. The fuel is deposited in the fuel valve *C*, out of which it is forced by the air charge at the proper moment. The air blast is supplied by the air compressor *D*, which is driven by a crank on the end of the engine shaft. In this diagram the air line is not supplied with a receiver or air bottle, and the air is delivered directly from the compressor to the fuel valve.

The parts enumerated are the essential parts of the Diesel engine. However the arrangements may differ, it is necessary that the unit include an air compressor, fuel pump, governor, camshaft and injection or fuel valve in addition to those parts generally found on an internal-combustion engine.

Fig. 4 represents the working diagram of a two-stroke-cycle. In Fig. 4 *F* the air charge is compressed from *b* to *c*. The fuel is injected when the piston reaches top dead center and the piston forced downward on the working stroke, making the lines *cd* and *de*, Fig. 4 *C*; at *e*, Fig. 4 *D*, the piston uncovers passages or ports in the side of the cylinder through which the exhaust gases pass. As the piston moves downward to the point *a*, scavenging valves in the cylinder head open, and a charge of pure air, which has been compressed in a large air pump or compressor to about 4 lb., blows into the cylinder, clearing it of all exhaust gases. At *b*, or slightly before this point, the scavenging valve closes, and as the piston moves upward, it seals the exhaust ports at the point *b*. Continued upward motion compresses the air charge until upper dead center is reached, whereupon the cycle is repeated. In some engines the scavenging valves in the head are replaced by a row of air ports which are uncovered by the piston at the end of the expansion stroke. The air flowing in through these ports clears the cylinder of the exhaust gases.

Improved Draft Gage of Cabinet Type

The two-tube gage shown was designed specifically to meet the induced-draft conditions in the new Calumet Station of the Commonwealth Edison Company. Some of the new features are an insulated back, straight glass

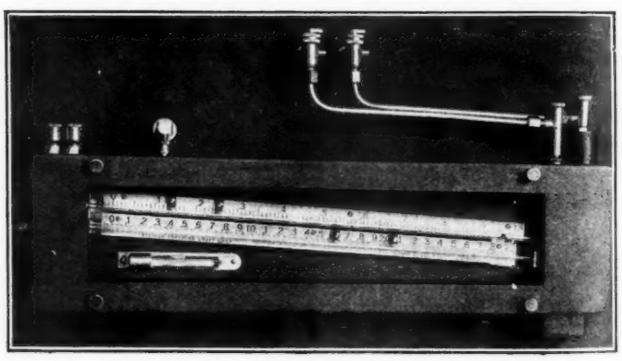


FIG. 1—NEW ENCLOSED DRAFT GAGE

tubes and flexible metal tubing connections, suspension from floating bearings to reduce breakage, screw adjustment for leveling, filters to seal all connections from dust particles, sliding scales for adjustment of the liquid to zero and liquid section seals in the cement cup at the chamber end. The casing has been extended to inclose the liquid chambers, to prevent excessive evaporation of the liquid. For the same reason the back of the casing is insulated when the location is such as to warrant this protection.

In the gage shown, the upper tube, which is connected with the furnace, reads up to 1½ in. of draft and the lower tube, connected over the last pass, reads to 3 in., the multiplications being 10 and 5, respectively. At the zero end flexible metallic bends connect to the terminals. Straight glass tubes cemented at both ends are used.

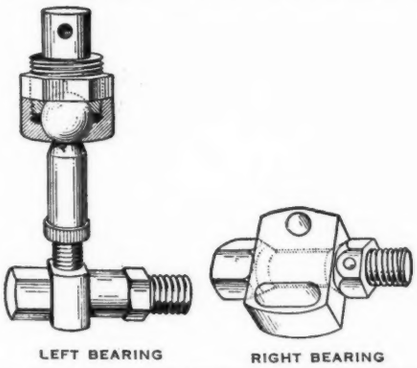


FIG. 2—FLOATING BEARINGS PERMIT MOUNTING ON UNEVEN SURFACES

As they are subjected only to tension and compression strains, breakage is reduced to a minimum.

Sliding scales, instead of the usual plungers, are used for adjusting the liquid to zero. The scales are actuated by adjusting screws at the left, the possible movement being 1 in. as compared to about ½ in. for the plungers. The pointers for limiting the range of operation are necessarily secured to the scales.

The conventional projecting ears by means of which a gage is screwed to the mounting surface have been eliminated, as with uneven surfaces it was difficult to secure the instrument without twisting the frame or breaking the glass.

Fig. 2 shows the floating bearings. The supporting element at the right turns on a pair of pivot bearings fastened to the gage frame. The slot permits alignment of the gage parallel with the board. The left bearing, also turning on a pair of pivot bearings in the bolt, is provided with a ball joint upon which the gage rolls in line with the right bearing in any position and upon which the gage moves freely under expansion changes. The bearing is provided also with a threaded socket for varying the incline of the gage.

This design of cabinet gage is being built by Lewis M. Ellison, Chicago, with one, two, three and four tubes.

Simplification of the Boiler Industry

At the June meeting of the American Boiler Manufacturers Association it was announced that the association had been invited to confer with the Division of Simplified Practice of the Department of Commerce, an outgrowth of the movement for the prevention of waste in the industries.

In compliance with this request a committee of the A.B.M.A. has submitted to the Division a memorandum setting forth the aims and purposes of the association and its activity toward simplifying the industry and reducing its waste.

After classifying the products of the industry, the memorandum sets forth that on account of the adaptation of each boiler to its particular surroundings, the variables that must be taken into consideration in the manufacture and use of steam boilers are so numerous as to make it impossible to build water-tube boilers for stock, and this is to a large extent true of fire-tube boilers. These and other variations from any standard construction and standard sizes, together with the ideas injected by purchasers, their consulting engineers, architects and operators, result in the manufacture of steam boilers being a "made-to-order" industry. The industry is not in any sense a merchandising one. The total number of contracts placed for such equipment per year is small compared with most industries, and practically every installation is different in some degree, large or small, from every other installation.

It will thus be seen that there are great difficulties in the way of standardization and simplification as these terms have been applied to articles that can be and are merchandized.

There are no statistics showing the total number of manufacturers of fire-tube boilers in the United States. There are approximately fifty manufacturers of water-tube boilers and relatively little export business by American boiler manufacturers.

The A.B.M.A. was organized in 1888 and at present consists of 77 member companies. Of these, 27 build water-tube boilers, 51 horizontal return-tubular boilers, 46 vertical fire-tube boilers and 38 locomotive-type boilers, all for land purposes. In addition 11 build water-tube marine boilers and 28 build Scotch marine boilers. The marine business is at present negligible. Further, 58 members build stacks and breechings and 55 heavy plate and tank work. The association has no information concerning the total normal or total maximum output of its membership.

Simplification and Standardization Activities

Notwithstanding the difficulties in simplification and standardization herein outlined, there have been several activities working to this end. The Boiler Manufacturers' Association has adopted as standards for steel and other materials the standards of quality adopted by the American Society of Mechanical Engineers Boiler Code. The majority of the members of the association are building all their boilers in strict accordance with the Code regardless of whether the boilers are shipped into the states that necessitate Code construction.

The Boiler Code Committee of the American Society of Mechanical Engineers has appointed a subcomittee to prepare rules for the inspection of steam boilers for the guidance of boiler manufacturers and those who are required by the various state laws to inspect boilers and the cost of their manufacture. The Boiler Manufecturers' Association is represented on this committee by three members.

The American Uniform Boiler Law Society was formed for the purpose of bringing about the legal adoption of the A.S.M.E. Boiler Code. It is supported to some extent financially and given active moral support in its promulgation of the A.S.M.E. Boiler Code by the Boiler Manufacturers' Association.

It became evident that the chief boiler inspectors of the various states were modifying the A.S.M.E. Code as it applied to their individual jurisdictions in minor details, but in such a way as to make it impossible for a boiler that had been passed and accepted in one state to be moved into some other state that had adopted the A.S.M.E. Boiler Code. This led to so many difficulties that chief inspectors of the various states that had

adopted the Code got together and formed the National Board of Boiler and Pressure Vessel Inspectors. These inspectors have agreed to pass on all variations from the Code that are proposed and to agree or disagree upon them, so that the various state laws and the rules of the state inspectors, as well as the requirements and qualifications of those who inspect boilers during construction and erection, shall be uniform. Furthermore, the National Board has agreed upon a form of stamp which is acceptable in the various states. The chief inspectors are members of the National Board. National Board stamping and registration are at present accepted in fourteen states and in six cities outside of those states. The National Board is receiving the hearty co-operation and assistance of the Boiler Manufacturers' Association, and its relatively small cost of operation is met by registration fees ranging from 25 cents to $3 per boiler, dependent upon the size of the boiler registered and stamped.

A large percentage of the power boilers are equipped with mechanical stokers, and a joint committee of the Stoker Manufacturers' Association and the American Boiler Manufacturers' Association has been successful in unifying the construction practices of boiler and stoker manufacturers in many respects concerning which they have all been in dispute in the adoption of better engineering, better construction and better operation of both boilers and stokers; and the agreements reached have undoubtedly aided in the conservation of fuel, less furnace brickwork and boiler and stoker repairs, and improved boiler and stoker performance.

Prior to approximately four years ago the members of the Boiler Manufacturers' Association would undertake to build boilers in pressures varying from one hundred pounds upward to any pressure an engineer or architect might demand. This resulted in different plate and tube thicknesses being used to meet these specific demands, always at increased cost to the manufacturer in the amount of stock necessary to be carried, the variation in design and in workmanship, all of which cost of necessity was passed on to the purchaser. Four years ago this association agreed to build all boilers for specific working pressures which cut down the different thicknesses of plate necessary to be carried in stock, and necessary to be ordered from plate manufacturers, to a considerable extent, and at the same time resulted in more nearly complete unification of details of construction, all at lower cost to the manufacturer and to the consumer.

A committee of the American Boiler Manufacturers' Association is co-operating with a similar committee from the Smoke Prevention Association looking toward the prevention of smoke and the standardization of smokeless settings, which will result in better fuel economy as well as more healthful communities.

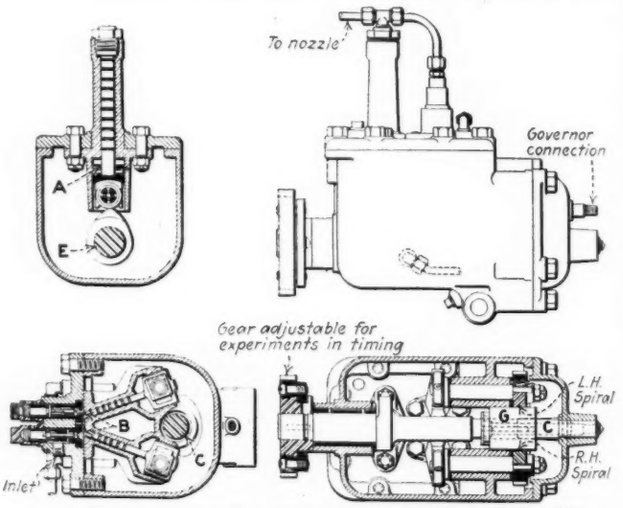
New Type of Oil Pump for Semi-Diesel Engines

For use with a solid-injection oil engine an injector or oil pump involving new principles has been designed by J. E. Guber, of Chicago. The pump was built for a small two-stroke-cycle engine and has functioned so well that its design is of general interest.

In this injector the liquid is metered in an element which is relieved from the high duty of injection, and the injection element is a second pump, arranged so that the factors ordinarily causing inaccuracy cannot affect the quantity injected. The liquid is drawn into metering chambers *B* by differential pistons during the entire half revolution of the crank, thus allowing maximum time for charging, and the discharge takes place during the other half of the stroke, the liquid passing from the metering chamber into the injection chamber from which its return is prevented by means of a check valve.

This chamber is always filled with oil, and the incoming charge must force the injection plunger *A* back into contact with its cam *E*. The amount of this displacement is exactly that of the charge, as the position of the plunger prior to being displaced was at the point where the injector cam left it after the preceding injection. Thus it is evident that the length of the effective injection stroke cannot be varied by wear, expansion of line or residue pressure, as it is fixed by the size of the charge introduced.

Reference to the accompanying illustration will show that the operation of the metering element is based on the differential principle. Two plungers work in con-



SECTION THROUGH FUEL INJECTION PUMP FOR SEMI-DIESEL ENGINE

nected cylinders *BB*. When both plungers move in the same direction at the same time, the maximum quantity of oil is pumped. When they move in opposite directions at the same time, no pumping occurs. Any other relative position of the cranks causes the pumping of a quantity between full and no duty, so that by changing the angular relation of the cranks infinite variations of quantity are obtained. This change is made by sliding the double-cut spiral gear *G* along the drive shaft *C*. As one crank is driven by a right-hand spiral gear meshing with the double-cut spiral gear and the other crank by a left-hand spiral gear, also meshing with the double-cut gear, the sliding of this double-cut gear shifts one crank forward and the other backward. Their relative positions determine the amount of oil forced into the injection chamber. The position of the sliding gear is controlled by the engine governor through a forked lever.

The actual introduction of oil into the engine cylinder is made by means of the cam *E* and the plunger *A*. After the contact between cam and plunger is broken, there is no pressure on the oil in the line. This should eliminate dribbling at the nozzle even after the smallest injection.

EDITORIALS

A New Angle on the Question of High Pressures

WILL steam pressures of twelve hundred pounds or even more come into commercial use during the next ten years? To answer this question definitely in the affirmative would probably be rash. A negative answer would seem equally rash in view of the facts brought out by George Orrok's "Commercial Economy of High Pressures and Temperatures," printed in this issue of *Power*.

The subject is one much discussed in recent years, but there has perhaps been a tendency to overemphasize the thermodynamic value of high steam temperature without sufficient consideration of the manner in which the temperature is obtained. This point of view naturally arises from the fact that the Carnot Cycle shows important gains in efficiency for increased temperatures. Since, however, there seems to be no practical way to operate power plants on the Carnot Cycle, there is left for practical consideration the ordinary Rankine Cycle and the regenerative cycle in which the feed water is successively heated by a series of bleeder heaters covering the entire range of temperatures from condensate to boiler water.

Now, as is well known, the efficiency of the regenerative cycle for saturated steam is equal to that of the Carnot Cycle. So, if efficiencies are plotted against temperatures, the curve for the Rankine Cycle lies well below that for the regenerative cycle. This applies not only where both are for saturated steam, but also where both take steam with the same amount of superheat. What is equally important is that the regenerative curves do not flatten out so quickly as the Rankine curves, so that the advantage of the regenerative cycle increases with the pressure. Yet even the Rankine cycle shows an important increase in efficiency as the pressure is increased with constant superheat.

On the theoretical basis, as well as from a practical consideration of the factors affecting the strength of materials, there seems to be much more advantage in raising pressures than in attempting to carry temperatures far beyond present limits. From this point of view the pressure should be maintained at the highest point possible.

As a preliminary basis of comparison, Mr. Orrok assumes in every case an actual over-all plant efficiency of 55 per cent of the theoretical. He then takes up, one by one, the various items of equipment that must be specially designed to withstand high pressures and temperatures. From boiler to turbine he finds no unsurmountable mechanical difficulties in the way of pressures up to one thousand two hundred pounds or more. In regard to temperatures his conclusion is different. Possibly a few hundred degrees beyond present advanced practice could be squeezed out by great refinement in design and construction, but it seems that nothing short of new discoveries can take us much beyond one thousand degrees F. Since the critical temperature of water is only 706 degrees F., which corresponds to a pressure of 3,200 pounds, there is plenty of room for pressure increase without going beyond the temperature limit.

What has been said concerns only efficiency gains and mechanical possibilities. Commercial application must hinge mainly on net gain, which in turn depends largely on increased cost. Taking Mr. Orrok's estimate of increased costs, increasing the pressure beyond two hundred pounds with either seven hundred-degrees or one thousand-degrees final temperature would give practically no net saving with the Rankine Cycle. With the regenerative cycle, on the other hand, there appears to be a considerable margin of net saving at two hundred pounds pressure, over the Rankine Cycle at that pressure. As the pressure rises, the net saving increases up to twelve hundred pounds, the limit of the diagram.

Before going to these higher pressures, engineers will want to know two things; (1) Is it mechanically practicable to operate at pressures somewhere around twelve hundred pounds and (2) has Mr. Orrok underestimated the cost? The first question has already been answered. Both boilers and engines have been built and operated at similar pressures. Way back around 1830 a small outfit was operated at one thousand pounds without difficulty. This and other historical experiments in high pressures are mentioned editorially in the September 12 issue of *Power*.

An answer to the second question cannot be given offhand. Moreover, it seems unlikely that any one plant would care to bear the heavy initial expense and suffer the inevitable experimental difficulties involved in a sudden jump to extremely high pressures. The normal and probable method of handling this will be for new stations to be built for higher and higher pressures, going up in small steps as long as no serious operating troubles appear and as long as the total cost of producing a kilowatt-hour continues to reduce.

Making Records of Plant Operation Available

THERE are cases where business enterprises of considerable proportions have been conducted with a degree of success with little attempt at keeping an intelligent record of the various transactions and their influence on the business as a whole. Likewise power plants of considerable size have been operated with fair success without keeping records of operation. But this is no argument against keeping records, since the lack of efficiency in most plants where little or no attempt is made at keeping a record of operation is sufficient to preclude any excuse for lax methods. It is well recognized that intelligent records are as essential to efficient operation as they are to success in business.

Just as there can be a deficiency of records, so can the keeping of them be overdone. Both lead to inefficiency. The former is caused by a lack of knowledge, and the latter involves the essential information into a mass of useless details that discourage its use. Any

system of records should be made as simple as possible and yet give the essential details. What will be well suited to a large plant where this work is handled by a staff of experts, would not be suited to the small plant where the operating engineer keeps the records. In the latter case a well-kept record of the coal delivered to the plant and fired, water fed to the boilers and the steam produced, kilowatt-hours generated, along with a record of the time of cleaning boilers, and making repairs to the more important equipment, will be much more effective in maintaining plant efficiency than any elaborate system requiring much of the operating engineer's time. Many features that are of little moment in a small plant, become of considerable consequence in the larger plants and justify the use of an extensive system of records.

Of equal importance to the keeping of plant-operating records is putting the material into such form as to be of the greatest value, which means that some easy method of comparing the operation of the plant day by day and month by month must be introduced. The log sheet and recording-meter charts for one month even in a small plant make quite a pretentious mass, and when filled in the ordinary manner it is not easy to obtain operating data from them. Furthermore, when once filed away, they are more likely to stay filed than they are to be carefully studied.

There is, in general, no simpler way of presenting data than in graphic form, and this method is used by many of the best-operated plants. On a letter-size sheet the coal consumed each day can be plotted, along with the pounds of water evaporated, from which the water evaporated per pound of coal can be determined and all three curves carried across the sheet for the month's operation. The average for the month may be transferred to a second sheet to show the average operation month by month for the year and the sheet that would be good for one month's daily operation would take care of two and one half years' monthly operation. All the essential details of the plant's operation can be presented in this way, so that not only daily operations, but also monthly and yearly operations, may be easily compared. Under such a system the engineer has at all times in easily accessible form a picture of what the plant is doing. The log sheets and recording-meter charts can be filed away and forgotten until something unusual arises, when reference can be made to them.

American Leadership in Engineering

WE AMERICANS are quite ready to admit that we lead the world in engineering. After making due allowance for patriotic bias, this is probably true in a general way. Surely, there can be no doubt about it, if such leadership can be measured in terms of miles of railroad, tons of coal and steel produced or of horsepower installed. "But," some foreign critic might say, "do you not know that some of the European countries have given more attention than you have to scientific research, which your own most prominent engineers admit is the basis of engineering progress." The answer is that this was true a few years ago, but it is probably not true today. The prestige of science in American industry has certainly been enormously increased in recent years. The geologist has become a practical adjunct of the oil- and coal-producing businesses. Almost every large industrial establishment has its research laboratory and research engineer, while testing laboratories are taken more or less as a matter of course. Fortunately, this change has taken place without injury to those practical qualities of mechanical ingenuity, energy, imagination and resourcefulness which, aided by rich natural resources, were more important than science in the early development of our industries.

Although Europe is suffering keenly from post-war difficulties, there has been some gain due to a realization of the fundamental importance of economy in production. Great Britain, in particular, which has always had a reputation for well-made machinery and equipment, will soon be equally noted for economical production, judging by the marked industrial changes that are reflected in its engineering journals.

If American engineering can maintain its leadership, not by holding back other countries, but by its own continued progress, no nation will suffer and no one will have cause to complain. To accomplish this, there must be better co-operation between American manufacturers to avoid expensive duplication of experimental work. There must also be more standardization, more courage in the elimination of obsolete practices and an even deeper appreciation of the fundamental value of science. If the goal is to be reached, all this must be done without loss of that spirit of practical initiative that first put American industry on the map. It is a big order, but there seems more than an even chance that American engineers will fill it, unless progress is blocked by what has been termed "low thinking in high places."

Interest in Exports Increasing

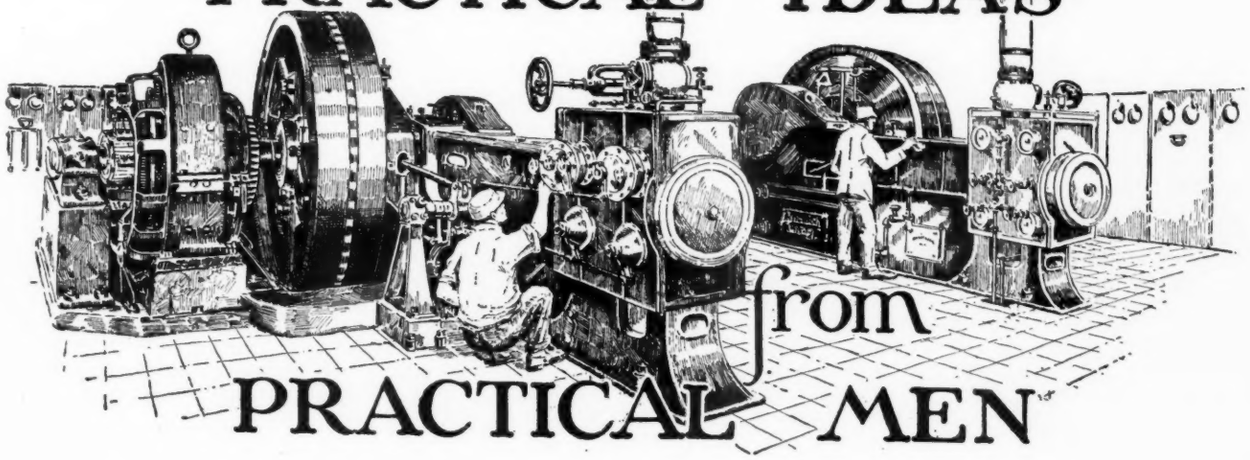
THAT there is a growing appreciation of foreign trade, in spite of present adverse exchange values, is indicated by the increased number of inquiries received by the Bureau of Foreign and Domestic Commerce. According to Dr. Julius Klein, head of the Bureau, it is now answering an average of thirty-two hundred inquiries a day as compared with eight hundred a year ago.

It is significant that both the markets and the character of our exports are changing. The volume going to the Far East is double what it was before the war, and instead of nearly all our exports being raw materials, as formerly, thirty-five per cent now represents manufactured products.

This applies especially to mechanical and electrical products, of which power equipment, such as turbogenerators, pumps, refrigerating machines and electrical apparatus, forms a substantial part. During the period preceding our entry into the war, competition from Europe was largely eliminated in these lines and much American equipment secured a foothold, especially in Japan, China and Canada, as well as certain South American countries. Duplicate orders and orders for parts have been a logical sequence.

Exports form a balance wheel to take up the slack in domestic demand even though the total may be comparatively small—fifteen to seventeen per cent of all we produce, as at present. However, many manufacturers, although perhaps not directly concerned, are indirectly affected by foreign trade and the subject warrants careful study of foreign buying power and local practices. The Department of Commerce is doing a real service, and the greater the use made of its facilities the greater will be the return.

PRACTICAL IDEAS from PRACTICAL MEN



Preventing Armature Bands from Breaking

Recently, I was called upon to make some repairs to a 500-kw. motor-generator set that had been running inverted, that is, direct-current input and alternating-current output. The owners were purchasing central-station alternating-current power, and it was desired to reverse the set so as to obtain direct current. The direct-current motor had six poles, operated at 1,200 r.p.m. and was originally shunt-wound and the pole-pieces were cast iron. Series-field windings and, later, interpoles were added to give stability. There was no provision made for armature wedges, the coils being held in place by fourteen bands.

Soon after starting up, these bands began to break, and investigation showed that the ends looked as though they had been heated. New bands were put on and the soldering clips were spaced at irregular intervals with the idea that they might have been generating enough current to fuse the bands. This had no effect whatever; the bands still broke. It was suggested that the solid polepieces might have something to do with it, but no one could explain why.

Steel and phosphor-bronze wire was used, but the effect was the same. Owing to the short air gap, rather small wire, No. 16 gage, was used with a single layer of fish paper under the bands. It was noticed that this fish paper was cut through in places, but no particular attention was paid to the fact. However, as a last resort, it was decided that this must have something to do with the trouble, so a new scheme was tried. Phosphor-bronze wire No. 18 gage was used with a layer of thin micanite underneath. These bands were soldered solid clear around. Upon starting again, the trouble was ended.

M. A. ANDERSON.

Pittsburgh, Pa.

Factors That Will Affect the Economy of Superpower

The fact that power is only one of many things that may be obtained from coal will undoubtedly not be overlooked in the plans for superpower.

I once operated a 2,000-kw. plant in which the prime mover exhausted into three single-effect evaporators. The vacuum on the liquors was maintained at 28 in., and the evaporators were capable of maintaining a 22-in. vacuum on the prime mover. With steam at 225 lb. gage, 100 deg. superheat, the steam consumption of the engine was about 16 lb. per kilowatt-hour.

The economics of the plant were interesting. At one time an incidental byproduct, made mainly by evaporating down previously wasted liquors, had a greater market value than the coal consumed by the plant, so the power might have been considered the byproduct, although the greater part of the investment was in power equipment. Multiple-effect evaporation of the liquors was impracticable owing to their corrosive action on the apparatus at high temperatures, so they could only be "boiled cold."

For the superpower enterprise proposed for the Atlantic seaboard, no doubt kilowatts will be the most essential thing to be derived from the coal. Heat may be next. Obviously, all the factories that require heat for processes and to heat buildings cannot be concentrated in the vicinity of the superpower stations, so it will still be necessary for many to generate their own steam for heating, unless a means is developed for long-distance transmission of heat. The byproduct gas plant will have a field here, but much remains to be done toward reduction of costs before central-station gas can be seriously taken into consideration for factory heating.

By passing the steam used for heating and processes through power units, a great deal of cheap power may be generated, cheap for two reasons—one that the heat chargeable to its generation is much less than for the superpower station, and the other the low investment per kilowatt delivered. Through co-operation this power may be used in processes that require large amounts of cheap power, possibly electrolytic work and electric furnaces. Some of this power may be saved by staggering the working hours of the various factories, and this would make a further saving by reducing the peak on passenger transportation equipment.

To obtain the highest economy, the byproduct power machines should be paralleled with the superpower system. Unless this is done, a large waste will occur. Many central stations, however, refuse to permit their customers to parallel small units with their systems. The net economic efficiency of superpower systems will be greatly reduced unless a satisfactory means is provided for utilizing the customer's byproduct power. Undoubt-

edly, it can be accomplished by, first and mainly a spirit of co-operation to make the thing a success, and secondly, by requiring the customer to install equipment of approved design and to maintain a high standard of operating conditions.

The matter of crediting the customer for the power he generates can be taken care of automatically. The unit value of the power he delivers to the line will be much less than of that which he receives.

Lansing, Mich. J. R. BELKNAP.

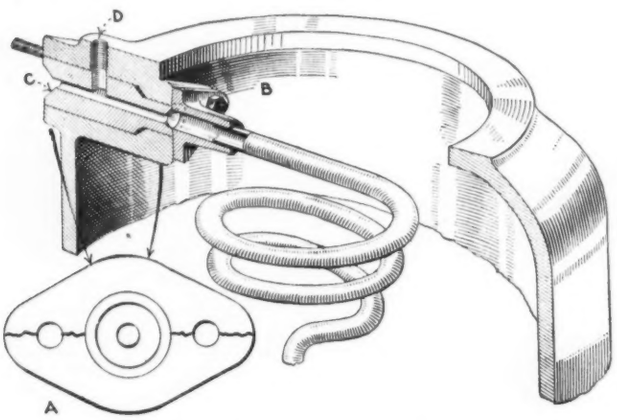
A Diesel-Engine Repair

In a central station where three Diesel engines carry a street-railway and lighting load, the compressor hood of one of the 500-hp. engines had fractured on the inside and outside, where the high-stage discharge air goes through the hood. The crack was in line with the studs holding the pipe flanges, which is shown at *A* in the illustration. The high-stage air leaked through the opening both into the cooling water space and outwardly to the atmosphere. This gave us a low injection air pressure and also prevented the proper circulation of cooling water in the dome. It became necessary to shut the engine down for repairs.

The air-compressor dome *B* was removed from the engine and mounted on a drilling machine. The air passage through the casting was drilled considerably large for about three-fourths of the way through the casting, and then a smaller drill was used.

A bushing was made from a piece of steel, with a hole drilled through the center of it the same size of the air opening in the dome casting before it was drilled larger. Each end of the hole was made bell-shaped to permit proper connection with the air-pipe and cooling coil.

The small shoulder left by the use of the two drills allowed a gasket to be used to prevent water from leaking out along the bushing. The bushing was put in under a drive fit. The hole *D* drilled through from the top is for the safety-valve connection. The machining job was completed, the dome replaced on the engine and the engine put back on the load with only a day's delay. It saved the expense of a new casting and also the time of a longer shutdown that would have been necessary in waiting for the new dome. The engine has been in operation for several months and the repair has shown no sign of a leak.

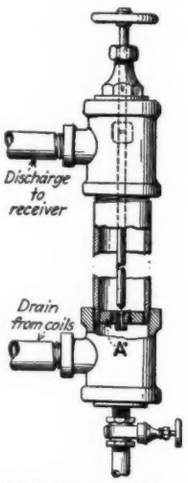


REPAIR OF AIR COMPRESSOR

Lincoln, Neb. MALVIN DAWS.

An Improvised Expansion Trap

An engineer, on taking charge of the power plant of a foundry, found that the condensate in the heating coils of an oven for drying small japanned castings was being wasted to the sewer. The drain pipe from the coils was fitted with a globe valve for controlling the condensation discharge. As it was difficult to adjust this valve, the coils would sometimes fill with water, and at other times steam would blow through the valve. The engineer decided to trap the condensate to a receiver and use it for boiler feed.



WHEN STEAM ENTERS TRAP, THE TEMPERATURE CAUSES ROD TO ELONGATE AND CLOSE VALVE

He constructed a trap to operate on the expansion principle, as shown in the sketch. A piece of 2-in. double-extra-heavy pipe, 36 in. long, was connected at both ends to tees with ¾-in. outlets. The top opening of the upper tee was bushed to receive the bonnet of a ½-in. globe valve. The lower end of the pipe was threaded inside and an iron bushing *A* containing a ¾-in. brass plug was screwed in. Through the center of the plug a $\frac{5}{16}$-in. hole was drilled and its upper edge was slightly beveled. The plug constitutes the removable seat. The stem which passes through the valve bonnet is coupled to a ⅜-in. brass rod, the lower end of which is beveled to conform to the bevel of the seat. By means of the valve stem the rod is adjusted so that its lower end stands about $\frac{1}{16}$ in. above the seat when the trap is cold.

When steam is turned into the heating coils, the water in them is discharged through the open trap valve, but when the steam begins to blow through, the heat of the steam expands the brass rod and the valve closes. Then, when the apparatus has been in service a short time and the working conditons become balanced, the slight opening of the valve will alternately increase and diminish, owing to variations in the length of the brass rod, so that the condensate will trickle out continuously. The lower tee forms a sediment chamber which can be blown out occasionally through the drain valve.

A. J. DIXON.

St. Louis, Mo.

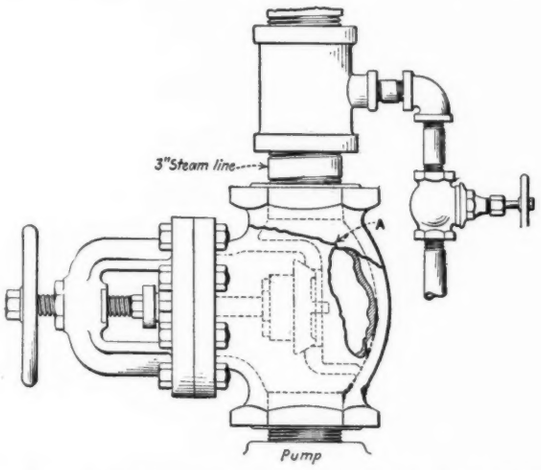
Another Break from Water Hammer

Few engineers or firemen realize fully the dangers of water hammer until they actually experience some accident caused directly by it.

The illustration shows the throttle valve of a fire pump that was recently broken by the action of water hammer. The pump is located about seventy-five feet from the boilers, and from the main steam-header to the pump throttle is a vertical drop of about nine feet. Directly above the throttle valve is a tee with a ¾-in. drain connected as shown.

In preparing to start the pump on the day of the accident, the engineer stated that he opened the drip valve about one-half turn (which would discharge water rapidly at 90 lb. pressure) and then proceeded to oil the pump and fill the lubricator, which took about ten

minutes. He then started for the boiler room and had gone only a few steps when the valve burst. The screwed end was completely separated from the body of the valve, as indicated by the line *A*, and a large piece was broken out of the side. The engineer reported that



A TYPICAL FRACTURE CAUSED BY WATER HAMMER

the pipe hammered from the time he opened the drain until the valve gave way.

"Safety first" is a good motto around a steam plant, and one way to practice it is to open all steam valves slowly. If water hammer starts, close the valve until all is quiet; then drain slowly until the pipe is clear.

Norwich, Conn. W. D. THROOP.

What Caused the Black Spots on the Commutator?

In our plant there are three 3-wire direct-current generators, all of the same make. No. 1 machine is rated at 600 amperes full load, 115 to 230 volts, has six poles, is compound wound with interpoles, direct connected to a steam engine running at 425 r.p.m. No. 2 generator is the same as No. 1. No. 3 machine is rated at 1,200 amperes, 115 to 230 volts, has eight poles, is compound wound with interpoles, direct connected to a steam engine running at 350 r.p.m.

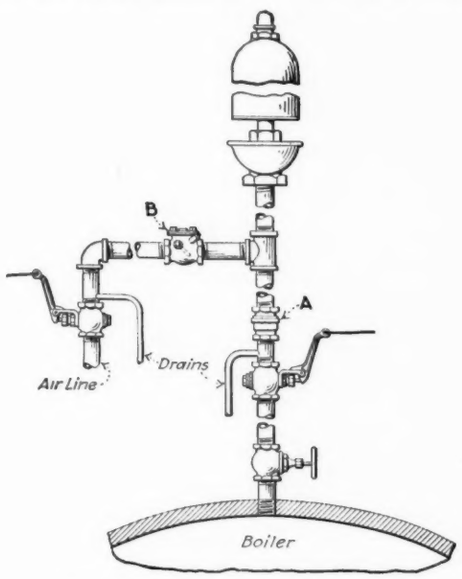
I have been troubled with the commutators on No. 1 and No. 2 generators, for the last three years. The six sets of brushes are equally spaced around the commutator and are set at the correct angle. The commutator is in good condition, also slip rings. No. 1 generator running alone for a month shows a fine polish on the commutator and is free from any sparking, but after running in parallel with No. 3 generator for four to five hours, during the peak load, blackened bars show up on No. 1 commutator. We dress up the commutator with sandpaper on a block having the same curvature as the commutator, but in a few days the blackened bars show up again in the same place. No. 2 generator acts the same as No. 1; when operating in parallel with No. 3 generator, the bars get black and rough. After a few days the blackened bars become more pronounced with clicking of the brushes as they pass under them. The commutator clamping rings have been tightened up and the mica undercut, but still we have the same trouble. Care is exercised in switching the machines in or out on the switchboard, and no sparking takes place during this operation. It is my opinion that the blackening of the bars develops when the machines are running in parallel and is not caused through switching. I would appreciate it if *Power* readers could give me suggestions to solve this problem.

It may be stated that in previous years we did not have to run No. 1 or No. 2 machines in parallel with No. 3 as the latter was able to take care of the load alone. No. 1 generator alone operates satisfactorily with no sign of sparking or blackening the commutator, likewise No. 2. Generators Nos. 1 and 2 run in parallel with no signs of sparking or blackening of the commutator, but with either No. 1 or No. 2 running in parallel with No. 3 then the black bars develop. As far as I know, we did not have trouble with any of our generators until we started paralleling with No. 3.

Montreal, Que., Canada. WILLIAM MACRAE.

Blowing Whistle with Steam or Air from Different Locations

It is often desirable to connect up a whistle so that it may be blown with either steam or air and from different locations. The method I used of doing this is shown in the illustration. The whistle line above the valve was cut and a vertical check *A* and a tee were inserted; the swing check *B* and a whistle valve were

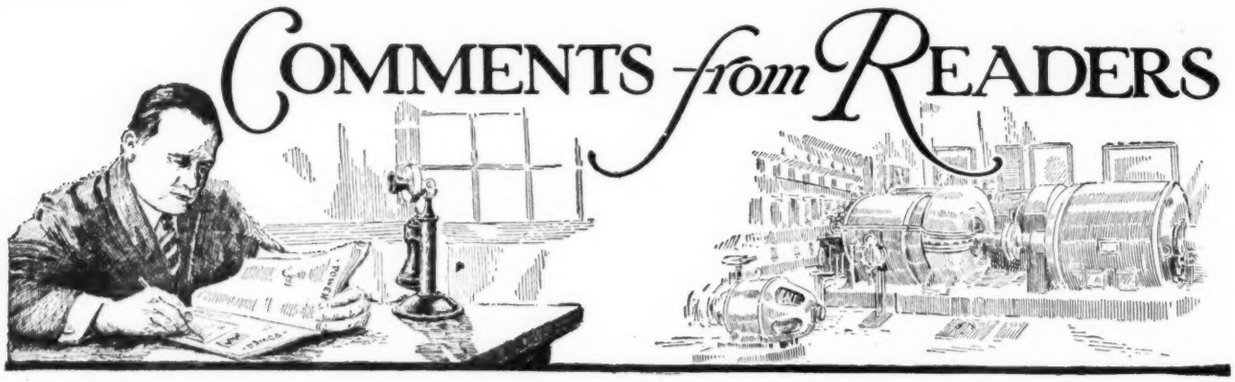


ARRANGEMENT OF CONNECTIONS

connected to the outlet of the tee and to the air line. The office of the check valves is to eliminate all danger of blowing steam into the air system, which operates at a much lower pressure than the boiler or the blowing of air into the boiler when the latter is down. The drains carry off any water that may collect in the lines.

North Canton, Ohio. E. W. BRONG.

No inspection should be considered complete that does not check the protection of the circuit. Have fuses been provided to protect all the wiring? Have fuses of the right capacity been used in these circuits? And are fuses of proper capacity being retained, or are wires, nails and all kinds of substitutes being used? No equipment can be considered safe unless attention is given to the correct maintenance of protective devices.



Comparative Tests on Coal and Oil

The letter by Albert A. Kral in the Sept. 19 issue, dealing with comparative tests on coal and oil states that efficiencies as high as 80 per cent have been obtained on tests with fuel oil, and that in his opinion the efficiency of 58 per cent for coal, as given in the original article under discussion, appears reasonable.

It is apparent that Mr. Kral is comparing test results on oil with operating results on coal. A first-class fireman, with high-grade coal, can obtain efficiencies around 72 per cent and mechanical stokers will give as high as 80 to 82 per cent when handled by an expert. There is no doubt that oil-fired boilers will, when properly handled, give equally high efficiencies. However, what most engineers are interested in are the results they can obtain every day from their plants. Let us assume, therefore, that the average small-sized plant, when fired with oil and operated by comparatively unskilled labor, will have an operating efficiency of 75 per cent. Under the same conditions, let us say for the sake of argument, the efficiency of a coal-fired plant would be 55 per cent.

Taking the prices of coal and oil in Eastern Canada as a basis of comparison, these run about $7.50 per ton for coal and 8.2c. per gallon for oil; 7.4 lb. evaporation (55 per cent efficiency) with coal at $7.50 per ton gives a cost per 1,000 lb. of steam of 50c.; 75 per cent efficiency with oil with a heating value of 18,000 B.t.u. per lb. works out at 13.8 lb. evaporation per pound of oil. The cost per 1,000 lb. of steam is therefore 89.5c. with oil at the price mentioned. It will be seen, therefore, that on this side of the line the fuel-oil proposition is not attractive from the viewpoint of fuel cost.

It seems unlikely that, when the price of coal becomes stabilized in the United States, the ratio of the costs of steam produced by the two fuels will differ greatly from the foregoing.

D. J. GRAHAME,
Chief Engineer the Under-Feed Stoker Company.
Toronto, Ontario, Canada.

An Examination Question

I was much interested in the article by R. G. Summers in the Oct. 3 issue. I do not think that he is looking at the matter correctly. The duty of examiners is to prevent incompetent persons from having charge of, or operating steam plants, and the questions they ask are the only means they have of judging the ability of the applicant. It is unfair to criticize them because they ask questions relating to a ball-and-lever type of safety valve or riveted joints. The law of levers should be known by every engineer even if it does apply to discarded valves. The reason why some engineers are asked concerning riveted joints is probably not that the examiner ever expects them to design joints, but to see if they realize how pressure affects a joint and how many different ways it is possible for a joint to fail and which way it is most likely to give way.

On page 509 of the Sept. 26 issue a problem and explanation of a butt and double-strap joint, double riveted is given. There are six different ways that a joint of this type can fail. (1) By the breaking of the plate between the outer row of rivets; (2) by the shearing of all the rivets; (3) by the breaking of the plate between the inner row of rivets and shearing off the rivets in the outer row; (4) by the breaking of the plate between the rivets in the inner row and crushing the butt strap in front of the rivets in the outer row; (5) by crushing the plate in front of the rivets in the inner row and crushing the butt strap in front of the rivets in the outer row; (6) by crushing the plate in front of the rivets in the inner row and shearing the rivets in the outer row.

In a well-designed joint the strength of the plate between the outer row of rivets is the weakest part of the joint. Therefore the strength of the plate between the rivets in the outer row divided by the strength of the solid plate will give the efficiency of the joint. In this case it was 82 per cent. Now this is what the examiners want to know if you understand when they ask you about a riveted joint. An examiner giving steam engineer licenses can examine an applicant only on boilers, engines and their appliances. The examinations on refrigeration or electricity are usually controlled by the police or some other commission responsible for the enforcement of the rules and regulations governing them.

BURTON W. WHEELER.
Rockland, Mass.

Temperature a Reliable Measure of Vacuum

The letter by J. C. Hobbs, in the Oct. 3 issue, is a strong argument for the use of temperature measurement as a means of determining the exhaust pressure. However, the writer wishes to differ from him in regard to a few points.

The argument from the relative quantities of air and steam is certainly in accord with the facts. The quantity of air usually present in any well-maintained condenser equipment is not sufficient to affect the temperature of the exhaust steam to any degree measurable by ordinary temperature measuring instruments.

In his seventh paragraph Mr. Hobbs touches the real point of the question, when he says that the thermometer must be so installed that the temperature of the

steam is determined rather than the temperature of the pipe. This is a difficult thing to do in most cases. For small turbines having exhaust pipes of moderate size the difficulties are lessened and some approach to accuracy may be attained; but in the case of large turbines, where the exhaust openings have a cross-sectional area, often well over 100 sq.ft., it is practically impossible to measure the temperature of the *steam* with any degree of accuracy. In no case can one be certain of the results. Errors arise from the conduction of heat along the thermometer well or thermocouple wires, and also by direct radiation between the thermometric element and the cooler or warmer metal surfaces to which the thermometer may be exposed. Another source of possible error is due to the high steam velocities prevailing in the exhaust of many turbines, which tend to give readings somewhat too high owing to the impact of the steam against the thermometer. These errors can all be minimized by special means, notably by the use of properly designed shielded thermocouples, but these at once depart from Mr. Hobbs' recommendation, which is that we use a thermometer in a well.

In one case in my experience, where an elaborate attempt was made to secure the average temperature in the exhaust passage of an 8,000-kw. turbine, the temperature, as indicated by an electric resistance thermometer, corresponded to a superheat of 30 deg. F., which, under the circumstances, was absurd. It later appeared probable that this high reading was due to radiation to the thermometer from hot metal which was in turn kept hot by heat conduction from the high-pressure end through the metal of the turbine casing.

It must be admitted that it is likewise difficult to measure accurately the pressure prevailing in a large exhaust passage. However, means have been developed by which the errors in pressure measurement may readily be reduced to a low figure, and it is my opinion that the use of mercury columns for the measurement of pressure directly is much more accurate and reliable than any temperature method yet developed.

The contention that the use of temperature alone will simplify computations and analysis is, to say the least, open to difference of opinion. C. HAROLD BERRY.

Detroit, Mich.

What Will Govern Future Boiler Inspection?

Boiler laws are presumably enacted, primarily, to insure safety of life and property. In direct contrast to this intention on the part of legislators is the action of several states in passing stringent "safety rules," in which all mention of the steam boiler is omitted.

While the steam boiler intended either for power generation or heating purposes is not necessarily dangerous in itself, it is made so by inefficient or careless operation. Even with careful and intelligent handling on the part of the men in charge, what success can be expected if a flaw exists in the boiler at the time of its purchase? It might be argued in this connection that the boiler is subjected to an inspection before it is put in active service, but in case the boiler is not to be insured and it is installed in a state whose laws do not require periodic inspection of such equipment, is such a process carried out as an inspection or in a "look it over" attitude? The latter method may disclose the flaw, but the chances are that it will not.

There is an ever-growing tendency for standardization in both machine and power-plant equipment in this country. This tendency is an outgrowth of "cost-cutting" and common sense with the common-sense element proving the stronger factor in every case. With regard to boiler inspection, however, common sense seems to have been placed on the shelf for safe keeping in many localities. While this condition is deplorable, it is by no means incurable, although strenuous methods are necessary if material benefit is to be derived.

Correspondence with state officials has disclosed the fact that the majority of states do not require inspection of boilers in any form.

Eighteen states have adopted, or are to adopt, the A.S.M.E. Boiler Code as their standard in inspection. Of this number, two Boiler Rule Boards report that this Code is to be adopted in its entirety in connection with the rules under process of formation at the present time. Two more states have placed slight restrictions upon some parts of this Code which they have adopted, only after finding such restrictions made necessary by local conditions. The remainder use the Code and are frankly favorable to any ruling of the American Society of Mechanical Engineers. Of the states requiring boiler inspection, only one fails to recognize the A.S.M.E. Code, and it seems that this particular state is unnecessarily emphatic in this regard, as an examination of this special code reveals the fact that it is fundamentally the same as that developed by the American Society of Mechanical Engineers.

No unfavorable comment has been made upon the A.S.M.E. Code by any of the states using it as their standard. This fact should be a strong recommendation toward its adoption by the remaining states of the Union. In view of this evidence of the results secured through using this Code, a uniform boiler law seems to be a concrete possibility.

The laws of one particular state require that all boilers shall be equipped with steam and water gages, but beyond this point there is no specification of any sort. One can but wonder how they know that these gages record correctly if they are not subjected to inspection at regular intervals. Of course we know that responsible engineers do inspect such equipment, but we are also aware of the fact that not all engineers and owners belong to this class. The latter class of engineers, if they can be so termed, seriously impair the success of any enterprise and can be held in check only by a rigid inspection of the equipment they operate.

Fruitful ground is open to A.S.M.E. Boiler Code advocates in each of the states not requiring inspection at the present. This statement is based upon the fact that many state officials report that they require no inspection, but that "a boiler inspected and installed in accordance with the A.S.M.E. Code will without doubt prove acceptable." Again insurance companies in each of these states constantly employ this code to the satisfaction of both contracting parties.

Interested engineers would do well to use every means at their command in an endeavor to bring the need of a uniform boiler law to the attention of those who are not so well informed on the subject, but who are in a position to assist in the work. No one cares to work in the neighborhood of a boiler that is at all liable to "let loose" at any minute, but unless he is fortunate enough to be employed in a state requiring periodic inspection, his chances for a free ascension are not at all bad. H. N. HITE.

Scranton, Pa.

QUESTIONS AND ANSWERS

Submergence of Pump Suction Pipe To Prevent Intake of Air

How much submergence below the still surface of the water should there be of the suction pipe for supplying water to a jet condenser to prevent admission of air? F. S. K.

To prevent eddies and whirlpools that could admit air, the ends of suction pipes usually are placed about four diameters below the surface of still water. That depth generally is found to be sufficient for suction-pipe velocities up to 200 ft. per minute.

Coating To Prevent Sweating of Pumps and Piping

We are considerably annoyed by "sweating" of a pump and pipe lines used for raising and distributing water from a well. What kind of paint or coating can be applied to prevent this condensation of moisture from the atmosphere? R. N.

A good non-conducting covering that is uninjured by moisture can be made of cork chips ranging in size up to that of very coarse sawdust. Clean the iron surfaces of the pipe and water end of the pump with a wire brush and give them two good coats of red-lead paint. Then apply a heavy coat of litharge, ground in oil, reduced to a thick paint with boiled oil, and press on as many cork chips as will stick fast. Apply a second coat of litharge and again dust on as many cork chips as will stick.

Steam Generated per Kilowatt

According to our recording water meter our boilers are supplied with 840 cu.ft. of feed water and the plant output is 1,530 kw. during an eight-hour run. After passing through the feed-water heater, the average temperature of feed water is 148.6 deg. F. The average pressure of steam generated is 140.4 lb. per sq.in. gage. What is the equivalent evaporation and how many pounds of steam are required per kilowatt? W. I. N.

Evaporation of 840 cu.ft., or 840 × 62.3 = 52,332 lb. of feed water for development of 1,530 kw., would be 52,332 ÷ 1,530 = 34.2 lb. of steam per kilowatt under actual conditions.

Each pound of dry saturated steam generated at the pressure of 140.4 lb. gage or 140.4 + 14.7 = about 155 lb. per sq.in. absolute, according to Marks and Davis steam tables would contain 1,194 B.t.u. The latent heat of evaporation, or heat required to evaporate a pound of water from and at 212 deg. F., is 970.4 B.t.u. Therefore with the feed-water temperature 148.6 deg. F. and assuming that the steam generated was 100 per cent dry, then under the stated conditions the factor of evaporation would be [1,194 — (148.6 — 32)] ÷ 970.4 = 1.1102; the equivalent evaporation would be 52,332 × 1.1102 = 58,099 lb. of water from and at 212 deg. F., and the steam used per kilowatt would be equivalent to 58,099 lb. ÷ 1,530 kw. = 37.97 lb. from and at 212 deg. F.

Cylinder Ratio for Two-Stage Compression

We require 500 cu.ft. of free air delivered per minute at 100 lb. pressure. If the compression is to be done in two stages, what would be the cylinder proportions and how are they calculated, based on an 18-in. stroke and volumetric efficiency 86 per cent, and what would be the horsepower required if the mechanical efficiency is 90 per cent and compression efficiency 70 per cent? R. D.

In compressing air from atmospheric pressure to a final pressure of 100 lb. gage (115 lb. absolute) in two stages, the work of compression should be divided as evenly as possible between the stages. The following table may be used to find the approximate value of the intermediate pressure.

Gage Pressure	Hp. for Single-Stage	Hp. for Two-Stage
10	3.6	....
20	6.28	....
25	7.42	....
30	8.47	....
40	10.30	....
50	11.9	....
60	13.41	11.70
70	14.72	....
80	15.94	13.70
90	18.15	15.40
100	....	....

In compressing air the actual work of compression is nearer to being adiabatic than isothermal, and most of the cooling of the air is done in the intercooler between stages.

In the table it will be seen that compressing from zero gage to 100 lb. requires 18.15 hp. per 100 cu.ft. of air with single-stage compression, while for two stages the horsepower is only 15.4. The difference is the heat removed by intercooling. To find the intermediate pressure, it is necessary to locate the pressure at which the work of compression from atmosphere equals the work of compression from the receiver pressure to 100 lb. By compounding two-stage compression to 100 lb. from atmospheric pressure, 15.40 hp. per 100 cu.ft. is required; one-half of this is 7.7 hp. In the table, compression to 25 lb. requires 7.42 hp. and to 30 lb. requires 8.47. So the receiver pressure should be between 25 and 40 lb., say 27½ lb. gage. The volume of air entering the high-pressure cylinder at 27½ lb. gage (43½ lb. absolute) will bear the ratio to the low-pressure cylinder volume that 43½ lb. bears to 15 lb., or 43.5 — 15 = 2.9. The ratio of the volume of the high to the low pressure cylinder volume is 1 to 2.9.

A compressor of 18-in. stroke should operate at about 100 r.p.m. Assuming a volumetric efficiency of 86 per cent, 500 cu.ft. of air to be delivered by the compressor requires $500 \div 0.86 = 580$ cu.ft., or 5.80 cu.ft. per r.p.m. = 2.90 cu.ft. per stroke. Since the volume of a cylinder $V = 0.7854\,d^2 \times$ stroke, the low-pressure piston area $= \frac{2.9\,d^2}{0.7854 \times 1.5}$, or $d^2 = 2.46$ sq.ft., $d = 1.568$ ft. = 18.8 inches.

The ratio of the squares of the cylinder diameters is 1 to 2.9; the diameter of the low pressure cylinder squared is 18.8×18.8 and the low pressure cylinder diameter would be $\sqrt{(18.8 \times 18.83 \div 2.9} = 11.4$ in., giving the cylinder sizes 18.8 and 11.4 × 18 in. stroke, speed 100 r.p.m.

According to the table the power required to compress to 100 lb. gage is 15.4 hp. per 100 cu.ft. or for 500 cu.ft. = 77 actual hp. Better proportions for the compressor would be a stroke of 12 to 14 in. and run at a higher speed, say 140 to 150 r.p.m., giving a compressor $18 \times 12 \times 12$.

Percentage of Heat Lost in Chimney Gases

If the temperature of the dry flue gases from a boiler plant is 475 deg. F. and that of the air entering the furnace is 65 deg. F., and 20 lb. of air is admitted for every pound of coal burned, using coal that has a heat value of 13,300 B.t.u. per lb., what percentage of the total heat value of the coal would be lost in the chimney gases? A. S. M.

Assuming that nine-tenths of the coal is combustible and therefore passes up the chimney in the products of combustion, the total weight of flue gas would be about 20.9 lb. per pound of coal burned. With the room temperature 65 deg. F. and flue gases at the temperature of 475 deg. F., the difference in temperature would be $475 - 65 = 410$ deg. F. The average specific heat of the flue gases would be about 0.25 and therefore the loss per pound of coal from hot gases passing up the chimney would be

$$20.9 \times 0.25 \times 410 = 2{,}142 \text{ B.t.u.}$$

This would represent a loss of $2{,}142 \div 13{,}300 \times 100 = 16.1$ per cent of the total heat value of the coal.

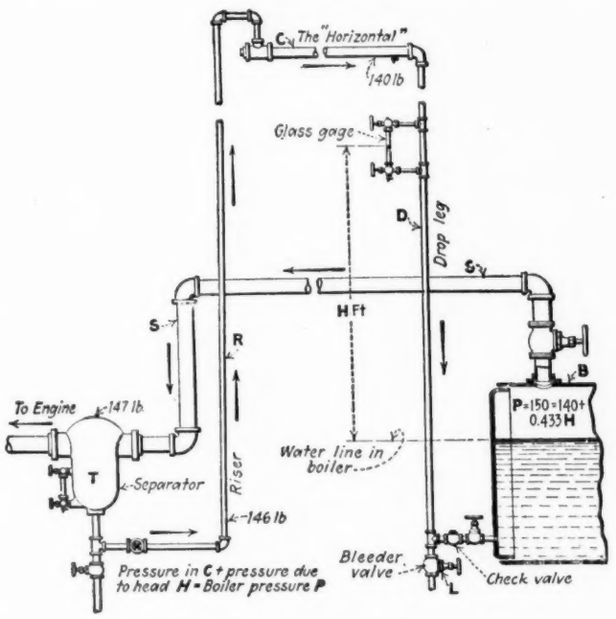
Arrangement and Operation of Simple Steam Loop

How is a steam loop arranged and how does it return water to a boiler without using a pump, trap or injector? L. H.

The sketch illustrates diagrammatically the arrangement and operation of a simple steam loop for automatically returning high-pressure drips from a steam separator *T* on a steam line *S* to a boiler *B* that is above the level of the separator. The principal parts are a "horizontal" *C*, and two vertical plain pipes *R* and *D* placed as indicated. One of the verticals, the riser *R*, is connected to the drain pipe of the separator *T* and also connected into the top of the horizontal *C*. The function of the "horizontal" *C* is that of a condenser. The drop leg *D* connects the lower end of the horizontal with the feed connection of the boiler.

The operation of the steam loop is as follows: Circulation is first started by opening the bleeder valve *L* at the foot of the drop leg *D*, until steam escapes. The bleeder valve *L* then is closed and the steam in the horizontal *C* condenses and the condensate gravitates to the drop leg *D*. Condensation continues in the horizontal *C* and on account of a slight reduction or pressure in *C*, a mixture of spray and steam flows from the separator *T* to the "horizontal." A column of water then builds up in the drop leg until its static head balances the difference of pressure in the riser *R* and the horizontal *C*, and further accumulation of condensate in the drop leg increases the head *H*, until the pressure due to the head plus the pressure in *C* on top of the water column in the drop leg *D*, is sufficient to overcome the pressure in the boiler and raise the feed check valve. Then discharge from *D* takes place to the boiler.

Assuming that one foot of head of water *H* is equal to 0.433 lb. per s.in., the pressure in the horizontal 140 lb. gage, and pressure *P* of steam in the boiler is 150 lb. gage, as indicated in the sketch, then as $P = 150 - 140 + (0.433 \times H$ ft.), for equilibrium $H = (150 - 140) \div 0.433 =$ about 23 ft. But for an increase of pressure in the "horizontal" or increase of the head



ARRANGEMENT OF SIMPLE STEAM LOOP

in the drop leg equal to the pressure necessary for opening the check valve and overcoming friction of flow, water in the drop leg would be discharged to the boiler.

Two or more separators may be attached to risers which discharge into the same horizontal, or separate drop legs of different steam loops may be connected into the same boiler-feed connection.

As air usually is liberated by condensation of steam, some will accumulate in the "horizontal," and unless drawn out, the operation of the system will stop. Hence, an air outlet should be placed in the "horizontal" to be operated at frequent intervals, or there should be a small opening for escape of air to the atmosphere. In a plant provided with a condensing engine, a small air bleeder connection may be made with the condenser.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Proposed A. S. M. E. Rules for Piping and Fittings

In connection with the proposed revisions of the A.S.M.E. Boiler Code (see *Power*, Oct. 17 and 24) the Boiler Code Committee has tentatively prepared, in co-operation with the American Society for Testing Materials, a new section giving specifications for piping and fittings used in connection with steam boilers. This was done at the urgent request of manufacturers, and because there was great need for such a set of rules.

This, as is the case with all matters connected with the Boiler Code, is a matter of vital interest to many engineers who have no connection with the Society. Recognizing this fact, the Committee desires that the proposed amendments and additions be subjected to the widest possible discussion and criticism before they are brought to a vote in the annual meeting of the Society in December. Discussions may be mailed to C. W. Obert, secretary to the Boiler Code Committee, 29 West 39th St., New York City, who will present them to the Committee for consideration. *Power* will also gladly open its pages to discussion letters of general interest, dealing with any portion of the proposed revisions or the following proposed rules:

Rules for Pipe, Pipe Material and Fittings Used on Steam Boilers

X-1. *Piping and Fittings.* The piping and fittings used on boilers up to the flanges for the connection of the first valves from the boiler on steam outlets, feed lines and blow-off lines shall conform to the rules given in *X*-1 to *X*-6, and it is desirable that all piping, valves and fittings used on steam and exhaust lines, including the vacuum system and drain lines; all water lines, including boiler-feed suction and discharge lines; and all boiler blowoff lines shall conform to them.

X-2. *Steam Pipe.* Piping for steam mains carrying saturated or superheated steam may be of welded or seamless pipe made of wrought iron or steel. For sizes above 3 in. in diameter the steel pipe shall be of open-hearth steel. All pipes shall be straight and free from blisters, cracks, laminations and other injurious defects. Liquor marks and lap-seam lines incidental to the manufacture of pipe will not be considered defects. Each length of pipe is to be inspected separately for defects on the inside and outside, noting particularly the character of the cross-section when cutting off crop ends. Pipe up to 3 in. in diameter may be butt-welded or lap-welded while that above 3 in. in diameter shall be lap-welded. Pipe material shall correspond with that required by the specifications of wrought-iron and steel pipe included in Par. *X*-9, *et seq.*

X-3. *Thickness of Steam Pipe.* In determining the thickness to be used for pipes at different pressures and for temperatures not exceeding 700 deg. F. the following formula is to be used:

$$P = \frac{2\,S(t - \frac{1}{16})}{D}$$

where

P = the working pressure in lb. per sq.in. above atmosphere.
t = thickness of wall in inches.
D = inside diameter of pipe in inches.
S = 3,500 lb. per sq.in. for seamless steel pipe.
= 3,200 lb. per sq.in. for lap-welded steel pipe.
= 2,500 lb. per sq.in. for butt-welded steel pipe.
= 2,500 lb. per sq.in. for lap-welded iron pipe.
= 2,000 lb. per sq.in. for butt-welded iron pipe.
= 2,000 lb. per sq.in. for brass pipe.
= 2,000 lb. per sq.in. for copper pipe.

X-4. *Feed Lines.* High-pressure hot-water and cold-water lines may be made of welded or seamless pipe of wrought-iron or steel as called for under *X*-2. Where the water contains corrosive material or air, brass or copper tubing may be used. In determining the thickness of water pipe the following formula will be used:

$$P = \frac{2\,S(t - \frac{3}{32})}{D}$$

where

P = water pressure in lb. per sq.in.
t = thickness of pipe in inches.
D = inside diameter of pipe in inches.
S = 2,625 lb. per sq.in. for seamless steel pipe.
= 2,400 lb. per sq.in. for lap-welded steel pipe.
= 1,875 lb. per sq.in. for butt-welded steel pipe.
= 1,875 lb. per sq.in. for lap-welded iron pipe.
= 1,500 lb. per sq.in. for butt-welded iron pipe.
= 1,500 lb. per sq.in. for brass pipe.
= 1,500 lb. per sq.in. for copper pipe.

Where brass pipe is desired for finish or for any other reason, it may be used. The brass and copper pipes used shall correspond to the specifications given under Pars..... and the brass pipe shall be half-annealed in order to leave it in proper condition for use in feed-water piping.

X-5. *Blowoff Piping.* Blowoff pipe is to be of extra strong size and to be made of genuine wrought-iron or steel as preferred.

X-6. *Pipe Bends.* Pipes when bent may be made of steel or wrought iron and after bending are to be free from buckles and blisters and practically circular in cross-section. They are to be bent before being threaded or flanged, and where flanged they are to be refaced to dimensions so that they may be bolted or faced without forcing. Where possible, the tangent length of pipe at the end of each bend should be of a length equal to at least twice the nominal diameter of the pipe, although tangents may be used with lengths which are equal to the nominal diameter of the pipe. The advisable radius to which pipe should be bent should be five or six times the nominal diameter of the pipe, although pipe may be bent to a radius equal to four times the diameter of standard pipe and three and one-half times the diameter for extra strong pipe up to 12 in. The thickness of the pipe is to be determined by the formula given in *X*-3. The boiler-feed-line bends are to conform with the above, while for blowoff lines the rules are to be applied to extra strong pipe.

Specifications for Welded and Seamless Steel Pipe

X-7. These specifications cover "standard" and "extra strong" welded and seamless steel pipe, but not "double extra strong" pipe. Pipe ordered under these specifications is intended for bending, flanging and other special purposes.

I—Manufacture

X-8. (*a*) The steel for welded pipe shall be of soft weldable quality made by the bessemer or open-hearth process. The steel for seamless pipe shall be made by the open-hearth process.

(*b*) Welded pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 in. in nominal diameter shall be lap-welded.

II—Chemical Properties and Tests

X-9. Open-hearth steel shall conform to the following requirement as to chemical composition:

Phosphorus.....not over 0.05 per cent

III—Physical Properties and Tests

X-10. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	Welded		Seamless
	Bessemer	Open-Hearth	Open-Hearth
Tensile strength, lb. per sq.in.	50,000	45,000	48,000
Yield point, lb. per sq.in.	30,000	25,000	26,500
Elongation in 8 in., per cent	18	20	18

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

X-11. (*a*) Welded pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

TABLE I—HYDROSTATIC PRESSURES FOR WELDED STEEL PIPE

(Black and galvanized. Pressures expressed in pounds per square inch.)

Size, (Nominal Inside Diameter), In.	"Standard" Pipe—Weight of Pipe per Linear Foot, Threaded and with Couplings, Lb.	"Standard" Pipe—Butt-Weld	"Standard" Pipe—Lap-Weld	"Extra Strong" Pipe—Weight of Pipe per Linear Foot, Plain Ends, Lb.	"Extra Strong" Pipe—Butt-Weld	"Extra Strong" Pipe—Lap-Weld
⅛	.....	700	.....	.....	700	.....
¼	.....	700	.....	.....	700	.....
⅜	.....	700	.....	.....	700	.....
½	.....	700	.....	.....	700	.....
¾	.....	700	.....	.....	700	.....
1	.....	700	.....	.....	700	.....
1¼	.....	700	1,000	.....	1,500	2,500
1½	.....	700	1,000	.....	1,500	2,500
2	.....	700	1,000	.....	1,500	2,500
2½	.....	800	1,000	.....	1,500	2,000
3	.....	800	1,000	.....	1,500	2,000
3½	.....	...	1,000	.....	.....	2,000
4	.....	...	1,000	.....	.....	2,000
4½	.....	...	1,000	.....	.....	1,800
5	.....	...	1,000	.....	.....	1,800
6	.....	...	1,000	.....	.....	1,800
7	.....	...	1,000	.....	.....	1,500
8	25.00	...	800	.....	.....	.....
8	28.81	...	1,000	43.39	.....	1,500
9	34.19	...	900	48.73	.....	1,200
10	32.00	...	600	.....	.....	.....
10	35.00	...	700	.....	.....	.....
10	41.13	...	900	54.74	.....	1,000
11	46.25	...	800	60.08	.....	1,000
12	45.00	...	600	.....	.....	.....
12	50.71	...	800	65.42	.....	1,000

or pipes over 12 in. in inside diameter, the test pressures should be calculated by the formula $P = 2St/D$, in which P = pressure in pounds per square inch; S = fiber stress = 12,000 lb. per sq.in.; t = thickness of wall in inches; D = inside diameter in inches.

(*b*) Seamless pipe shall be tested at the mill to hydrostatic pressures not exceeding that required by the formula,

$$P = \frac{2 S t}{D}$$

in which P = pressure in pounds per square inch; S = allowable fiber stress = 16,000 lb. per sq.in.; t = thickness of wall in inches; and D = inside diameter in inches.

X-12. (*a*) For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

(*b*) For butt-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is 60 per cent of the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

X-13. For pipe 2 in. or under in diameter, a sufficient length of pipe shall withstand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

X-14. (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

X-15. One of each of the tests specified in Pars. *X*-10, *X*-12 and *X*-13 may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

X-16. If the results of the physical tests of any lot do not conform to the requirements specified in Pars. *X*-10, *X*-12 and *X*-13, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

IV—Workmanship and Finish

X-17. For pipe 1¼ in. or under in inside diameter, the outside diameter at any point shall not vary more than 1/32 in. over nor more than 1/32 in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

X-18. Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of standard welded pipe shall be threaded.

(*b*) Extra strong welded pipe and standard and extra strong seamless pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be made of wrought iron or steel.

X-19. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

V—Inspection and Rejection

X-20. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

Specifications for Welded and Seamless Wrought-Iron Pipe

X-21. These specifications cover "standard" and "extra strong" welded wrought-iron pipe, but not "double extra strong" pipe.

X-22. All pipes to be used on locomotives and cars shall be of coiling or bending quality.

I—Manufacture

X-23. (*a*) The iron shall be made from muck bars, made from puddled pig iron, free from any admixture of iron scrap or steel.

(*b*) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.

X-24. *Iron Scrap.* This term applies only to foreign or bought scrap and does not include local mill products, free from foreign or bought scrap.

II—Physical Properties and Tests

X-25. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq.in.	40,000
Yield point, lb. per sq.in.	24,000
Elongation in 8 in., per cent	12

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the crosshead of the machine shall not exceed ¾ in. per minute.

X-26. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

X-27. A section of pipe 6 in. in length shall be flattened until broken by repeated light blows of a hammer or by pressure; the fracture developed shall have a fibrous appearance.

X-28. For pipe 2 in. or under in diameter, a sufficient length of coiling or bending pipe shall withstand being bent cold through 90 deg., around a cylindrical mandrel the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

X-29. (*a*) Test specimens shall consist of sections cut from a pipe. They shall be smooth on the ends and free from burrs.

(*b*) Tension-test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

X-30. One of each of the tests specified in Pars. *X*-25, *X*-27 and *X*-28 may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

X-31. If the results of the physical tests of any lot do not conform to the requirements specified in Sections *X*-25, *X*-27 and *X*-28, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

III—Workmanship and Finish

X-32. (*a*) For pipe 1¼ in. or under in inside diameter, the outside diameter at any point shall vary not more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall vary not more than 1 per cent over or under the standard size.

X-33. Unless otherwise specified, pipe shall conform to the following regular practices:

(*a*) Each end of standard pipe shall be threaded.

(*b*) Extra strong pipe shall be furnished with plain ends.

(*c*) All threads shall be in accordance with the American standard and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

(*d*) Each length of threaded pipe shall be provided with one coupling, having a clean-cut thread of such a pitch diameter as to make a tight joint. Couplings shall be of wrought iron.

X-34. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

IV—Inspection and Rejection

X-35. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of charge, all reasonable facilities to satisfy him that the pipes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

X-36. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

Looking Ahead in the Coal Industry

Emphasizing the danger of believing that our natural resources are inexhaustible, and offering constructive suggestions for regulation of the coal industry, Floyd W. Parsons, editorial director of the *Gas Age-Record*, gave an interesting talk before the Western Society of Engineers in Chicago on Oct. 9, on the future of the coal industry in America.

The world has used more of its mineral resources during the last twenty-one years than in all the years that have gone before, said Mr. Parsons. The United States in particular is wasting fuel with the utmost abandon, regardless of the fact that minerals cannot be duplicated like the products of the soil. Our stock of high-grade iron and copper ores is being depleted rapidly. Our petroleum reserve is dwindling, and more coal has been used in the last thirteen years than in the century preceding. More than a third of the high-grade coal of the country has been exhausted, and while there is more coal than any other fuel, the supply must be conserved in every possible way.

In the opinion of the speaker, the coal situation is one of the most vital problems of the day. More than six tons per capita annually is burned. The recent strike, controlled by one man, has cost the nation $1,200,000,000, more than the income from the entire agricultural industry. The resulting shortage has forced the use of soft coal in many of the Eastern cities, thus aggravating the smoke nuisance, which costs London $30,000,000 and Chicago $18,000,000 a year.

Believing that there will be no peace in industry until the coal industry has been subjected to some form of regulation, Mr. Parsons suggested that the following things be done: First, a permanent bureau of coal economics should be established, to furnish the country with the real truth concerning wages, prices and all details relating to the supply of coal. Second, the term "fuel emergency" should be defined by law. Some figure must be set as a minimum below which the total coal supply of the country must not pass—say, for example, a four weeks' supply, or about 30,000,000 tons. Then, during a strike, when the supply dwindles nearly to this minimum, the President may announce an emergency. Then comes the third factor—compulsory arbitration—provision for which already should have been made. With the permanent bureau mentioned, having all the facts available, a verdict might be rendered in two or three days. In case either side refused to abide by the decision, the government would then take over the industry and operate it until a settlement was reached. Even if the cost of such regulation amounted to $500,000,000, it would still be $700,000,000 below the cost to the country of the last strike. When this menace threatening the welfare of the country is eliminated, said Mr. Parsons, the coal industry will then be truly stabilized.

The production of coal is not as seasonable as is generally believed. During the six warmer months, production averages about 43,000,000 tons per month and in the other six months about 57,000,000 tons. Much can be done, however, by storage and proper distribution of buying to even up production, making it possible for the mines to operate more efficiently and relieving the railways during the colder months when haulage is more expensive.

Mr. Parsons expressed a belief in the coming of a gas age. It is barbarous, he said, to burn coal in the raw state without distilling off and conserving the various volatile byproducts. He believes that the future will see great super-energy stations supplying electricity for power and gas for heating, with gas mains extending over the country as do our present electric transmission lines.

The Fuel Situation in Canada

Canada is today in the grip of the second fuel famine in four years, due directly to industrial disturbances in the United States. That country supplies the major portion of Canada's fuel, both solid and liquid. The serious situation thus created by industrial disturbances in the United States has caused many in Canada to ask why this unfortunate condition can exist in a country so generously supplied with coals of all kinds, with the possible exception of an anthracite equal to that mined in Pennsylvania.

The problem with which Canada is concerned, however, according to a report by B. F. Haanel, Chief of the Division of Fuel Testing, is one of distribution rather than supply. Canada's coal fields are situated in the extreme east and west, in the provinces of Alberta, Saskatchewan, British Columbia and Nova Scotia, so that the long stretches of intervening territory, comprising the provinces of Manitoba, Ontario and Quebec, can obtain good American coal at a lower price than that economically possible for Canadian coal.

"Although Manitoba is practically devoid of economic coal resources," says Mr. Haanel's report, "it appears today that this handicap is being rapidly overcome through the introduction of domestic fuels of good quality from Alberta. Manitoba is learning to use the Alberta coals for industrial and domestic purposes, and so, as regards coals, the fuel problem of the western provinces should not be regarded as a serious one.

"Ontario and Quebec, however, are in a more unfortunate position, since the industrial and thickly inhabited portions of these provinces are too far removed from western coal fields and do not appear to be drawing very heavily on the coals which are mined in Nova Scotia, principally because United States coal is able to compete in price and quality

with the Nova Scotia coal. It is therefore evident that the fuel problem, so far as these provinces are concerned, may be narrowed down to one of transportation. It is not likely that Canadian coals either from the east or the west will ever be able to compete with United States industrial coals.

"While this is true with respect to bituminous coals for industrial, railway and metallurgical purposes, it is not true with respect to anthracite, which is mainly imported for domestic purposes. It is quite probable that anthracite will not be available for exportation in the comparatively near future as the United States supplies are becoming limited. In fact, it has been estimated that at the present rate of production, the anthracite fields will be exhausted in the course of the next eighty years. A substitute will consequently have to be found.

"A large quantity of coal is used for gas making, and practically all of this coal is obtained from United States sources. This is due to the high sulphur content of the Canadian coals available for this purpose. This pertains principally to the coals which are mined in Nova Scotia, but it is not improbable that a process could be devised for reducing the sulphur content of these coals, thereby rendering them suitable for gas making.

"With regard to the supplies of crude and refined oils, the demands for which are increasing at an exceedingly rapid rate, the situation is entirely different. Up to the present time Canada has not developed any large oil fields. At least 98 per cent of her oil requirements are obtained from the United States and from other countries, and even though oil products manufactured in Canadian refineries are put on the market, the source of these refined products is foreign. It is probable that in time an oil field of large proportions will be found in Canada, but until that time Canada will be dependent almost entirely on foreign sources for her crude oil."

Operating Results of a Large Power Station

An interesting article in *Engineering*, Sept. 1, 1922, describes performances in the Dalmarnock Station of the Glasgow Corporation, a description of which appeared in *Power*, Sept. 6, 1921. Five 23,000-kw., maximum rated turbine units are now operating on 275-lb. steam at 700 deg. F., and five more will be added eventually.

A method of calculating devised by Mr. R. H. Parsons, which permits a direct comparison between the operating efficiency of the different shifts, notwithstanding the varying conditions of load, and also the average rate of consumption for any station load, is utilized.

The total coal used for each shift is plotted as ordinates, with total kilowatt-hours generated per shift as abscissas. A line drawn through these points, totaling three per day, gives average totals for all station loads, indicating that at zero load, losses require approximately 20,000 lb. coal per eight hours. As the average conforms satisfactorily to a straight line, it follows that an equation of total coal for any output can be devised, which in this station is

$$C = 20{,}000 + 1.716\,K \qquad (1)$$

where C = number of pounds of coal at the chosen shift electrical output and K = electrical output per shift in kilowatt-hours. The average coal consumption per kilowatt-hour for any shift load can be plotted from the line established.

Steam consumption may be handled in the same manner, so that results of the various shifts can be compared and an average equation developed, which is

$$W = 100{,}000 + 11.535\,K, \qquad (2)$$

where W = number of pounds of water per shift.

At 240,000 kw.-hr. per shift, this plant shows a coal consumption of 18.4 lb. per kw.-hr., and steam consumption of 11.9 pounds. Combining the two equations, a third relationship may be expressed as

$$C = 5{,}123 + 0.1487\,W \qquad (3)$$

$$W = 6.722C - 34{,}400 \qquad (4)$$

These constant no-load losses amount to only 20,000 lb. of coal per shift. This is remarkably low for so large a plant as Dalmarnock, for it must be remembered that this is the quantity of fuel required to make up all radiation and condensation losses in both engine and boiler room and to keep the plant for eight hours in a condition ready to pick up a small load without any notice at all. This implies that one turbo-generator would be running all the time fully excited at no load, and that the necessary auxiliary machinery would also be in operation.

Equation (3) shows that, if no water were to be evaporated, the coal consumption of the station would be 5,123 lb. per eight-hour shift, and (4) shows that the greater the load on the station the more nearly the evaporation approaches the value of 6.722 lb. of water per pound of coal. The coal at Dalmarnock is analyzed daily, and during the four weeks period considered it had an average value of 10,500 B.t.u. per pound. Taking the feed-water temperature on entrance to the economizers as 141 deg. F., the theoretical amount of heat required to turn a pound of this water into steam at 274 lb. per sq.in. gage pressure and 700 deg. F. temperature is 1,264 B.t.u. This corresponds to 0.1204 lb. of the fuel used, so that the boiler plant is approaching a limiting efficiency of 80.92 per cent.

Returning to the question of no-load losses, it has been pointed out that equation (1) indicates that to maintain the station in a stand-by condition for an eight-hour shift would involve a consumption of 20,000 lb. of coal. If W were made zero in equation (3) the coal consumption during a shift would be only 5,123 lb. Making W equal to zero, means the evaporation of no water, so that one may deduce the fact that to maintain the boiler plant with regulator valves and junction valves shut, but with full steam pressure, and therefore ready to supply a small amount of steam at no notice, would require 5,123 lb. of coal per shift. This quantity of coal therefore represents the radiation and other heat losses in the boiler room, and the difference between 20,000 and 5,123—namely, 14,877 lb. of coal—corresponds to the heat losses in the engine room. These include the no-load consumption of a turbine and its auxiliary machinery, the condensation losses in steam pipes, etc. The coal in question is indeed that required to generate the 100,000 lb. of steam per shift which the station consumes at no-load, as seen from equation (2), and it effects this evaporation at the standard rate of 6.722 lb. of water per pound of coal. We thus have, by this method of analysis, a method of estimating with fair accuracy, the coal and steam consumption required to make good the stand-by losses of the station, and moreover we can apportion those losses between the engine room and the boiler room.

Chemical Society Takes up Oil-Fuel Problems

To insure future supplies of motor fuels and oils, a special committee of the American Chemical Society has begun the investigation of a series of problems submitted by W. F. Farragher, of Mellon Institute, at the recent meeting of the society in Pittsburgh. The most important of these problems are as follows: Thorough scientific investigation of fractionating columns; rational specifications for petroleum products based on actual research work; the degree of refinement of gasoline for motor fuel; a thorough study of lubrication from a colloid chemical viewpoint; and the chemistry of petroleum hydrocarbons. The work is being directed by the American Petroleum Institute.

Argument on the three sets of suits involving the validity of the Pennsylvania coal tax and valuation laws will be heard by the United States Supreme Court on Nov. 13. Both sides urged that these test cases be expedited, so that if the decision of the Supreme Court be adverse to the state, the legislature may have ample time to adjust its actions, regarding appropriations and otherwise, in accordance with the ruling. The principal fight is against the tonnage production tax and in this case several New England States are preparing to intervene on the ground that they have primary interest because the tax would increase the cost of coal to their consumers.

News in the Field of Power

New York N.A.S.E. Members Will Hear Many Technical Lectures

That the local associations of the N.A.S.E. in Greater New York and vicinity are preparing for intense educational activity this winter is indicated by a list of available lectures sent out by D. L. Fagnan, first district chairman of the New York State Association Educational Committee. One hundred and one lectures are listed, covering everything from superheated steam to oil production and from ethyl-chloride refrigeration machines to hydraulics.

Most of these lectures are illustrated with lantern slides or motion pictures. The following partial list will give an excellent idea of the wide range of subject matter: Superheated steam and superheaters; absorption, compression and carbonic (CO_2) refrigeration systems; modern elevators; storage and reclaiming of coal; power-plant instruments; heat balance; poppet valves and unaflow steam engines; indicators and reducing motions; mechanical stokers; feed-water regulators and systems of control; Diesel and semi-Diesel oil engines; centrifugal and reciprocating pumps, all types; condensers; automatic combustion control systems; heating, ventilating and exhausting systems; making of charcoal iron boiler tubes—ore to finished product; modern systems of feed-water treatment; efficient operation of oil-burning steam plants; internal-combustion engines of all kinds—a review; trouble chasing in the electrical end of the power plant; synchronous motors; the slide rule thoroughly explained in one hour's talk; modern ash and soot disposal systems; underfeed stokers versus overfeed stokers, etc.

The complete list may be obtained from D. L. Fagnan, 1080 Simpson St., New York City.

Kind of Coal, Not Quality, Causes Firing Trouble

Changes in the kind of coal used, rather than poor preparation at the mine, are responsible for firing troubles nowadays according to G. S. Pope, chief engineer of the Government Fuel Yards.

While it is to be expected that under present production conditions miners will not be as thorough in cleaning their coal as usual, Mr. Pope declares that poor preparation is not responsible for one per cent of the trouble caused by a change in the character of the coal used. Coal differs so greatly in volatile, ash and other qualities that the same results cannot always be obtained by the same method of firing coal from two mines comparatively close together.

"In the government plants at Washington," said Mr. Pope, "we are now getting coal from 43 different mines where before we were supplied by two. The situation is annoying but there is no help for it, and our combustion problems are being solved mainly by thorough investigation of the firing conditions when using each grade of coal. The same steps must be taken in other plants using a new grade of coal for the first time."

Coal Commission Will Summon Specialists To Aid Work

With John Hays Hammond as chairman and E. E. Hunt as secretary, the United States Coal Commission has plunged into its work of inquiry and investigation.

No formal announcement has been made as to procedure, but certain policies already are apparent. First, the Commission intends to keep the public informed as to each step of its progress, recognizing that the only chance it has to accomplish anything is to secure public support for its recommendations. Second, the problem is so complex that the Commission expects to call to its aid specialists from each subdivision of the coal industry. One of its first acts was to invite into informal conference John L. Lewis, president of the United Mine Workers of America; Alfred M. Ogle, president of the National Coal Association, and S. D. Warriner, a leading anthracite operator. Each was asked to appoint a consulting committee, which is to maintain close contact with the Commission and assist it by presenting such facts as may be called for from time to time.

E. E. Hunt, secretary of the Commission, has been in charge of a study of intermittency in the coal industry since last March. It is reasonable to suppose that, in taking up the work of the Coal Commission, Mr. Hunt will resort to much the same form of organization that functioned so successfully during the President's Unemployment Conference and during the Conference on Limitation of Armament. At those conferences advisory committees were used with great success. For instance, an advisory committee on storage would be composed of representatives of coal operators and of large consumers—those most likely to benefit or be interested in storage. The adoption of such a plan by the present Commission would save a large amount of work and would furnish the Commission with much predigested material.

Advantage must be taken of all means to expedite the study in order that the Commission's preliminary report may be completed on the specified date, Jan. 15.

The eight B. & W. water-tube boilers for the Brooklyn Edison Company's new 400,000-kw. station are to have 19,650 sq.ft. of heating surface each, instead of 16,950 sq.ft. as announced in the Oct. 10 issue.

New York Water-Power Case Goes to Supreme Court

The United States Supreme Court has set Jan. 2 as the date for hearing arguments on the motion to dismiss the suit of the State of New York against the attorney-general and others, which is a test case of the constitutionality of the water-power act and the authority of the Federal Power Commission.

Suit was filed some months ago by New York, claiming that the Federal Power Commission was exercising authority over non-navigable streams and depriving the state of revenue it otherwise would receive through its own regulation of water-power rights within its boundaries. The Federal government filed a motion to dismiss this action as without merit and asked an early hearing, which has just been set for the first Tuesday of the new year.

New Water-Power Company Will Handle 98,000 Horsepower

Hydro-electric power developments and sites in northern New York State totaling 98,000 hp. have been acquired by the Power Corporation of New York, whose organization was announced on Oct. 25.

The new corporation, capitalized at $1,000,000 preferred stock and 300,000 shares of no par value common stock, with $5,000,000 in bonds authorized, has bought from the Hanna Paper Corp. and the St. Regis Paper Co. the water powers at the six mills of these companies, developing some 38,000 hp. In addition, the corporation has acquired potential water powers on the Raquette River near the power properties of the Aluminum Company of America, capable of developing 60,000 hp.

The object of the corporation is to facilitate the distribution of surplus water power generated at the paper plants. At present, the shutting down of any of the St. Regis or Hanna mills results in idleness of the power plants; under the new plan, all the power in excess of that used for paper manufacture will be available for commercial distribution. When a mill is shut down completely, the entire output of its power plant will be turned into the corporation's transmission lines.

The powers turned over to the Power Corporation are located at Deferiet, Herrings, Norwood, Norfolk, East Norfolk and Raymondville. Interests affiliated with the Northern New York Utilities, Inc., and the Northern New York Trust Co. will back the new organization, whose president is John N. Carlisle and whose directors are Floyd L. Carlisle, Frank A. Empsall, John J. Warren, R. M. Maltby, W. K. Dick, J. Adolph Mollenhauer, Jonathan Buckley, Alvah Miller, Thomas J. Walsh and W. P. Creager.

Form Committee To Co-ordinate Power-Plant Research

To prevent undesirable duplication of effort and to allocate subjects of investigation to the proper bodies, a committee on co-ordination was formed at the recent meeting of the technical sections of the National Electric Light Association at Milwaukee. This committee will consist of the chairmen of several technical committees, as follows: The electric machinery and power station committees of the A.I.E.E., the prime movers and electrical-apparatus committees of the N.E.L.A., the committee on power generation of the American Electric Railway Association and the steam turbines and generators committee of the Association of Edison Illuminating Companies. Representation was desired from the A.S.M.E., but this society is so organized that there are no committees whose work corresponds in scope with those of the associations represented.

This movement toward co-ordination of engineering activities was begun last January at a meeting of the chairmen of several of the committees of the American Institute, the N.E.L.A. and the Edison associations, all dealing with power-station problems. At the recent Milwaukee meeting the chairman of the power-stations committee of the American Institute was elected chairman of the co-ordinating commmittee. While the American Institute deals particularly with the technical and scientific side of the power-plant problem, the other committees are interested in new developments, operating problems and applications of equipment. Working alone, the various organizations would tend to duplicate each other's work, and it is this duplication that the co-ordinating committee hopes to eliminate.

Southern Power Company To Build Two Steam Plants

The installation of two large reserve steam-electric plants in the near future by the Southern Power Co. will more than double its present steam generating capacity. These plants are to be used for stand-by service; one of them, to be rated at 40,000 hp., will be built at Mountain Island, N. C., where the company is also building a large hydro-electric plant; the other, of 20,000 hp., will be at Eno, N. C., where the company is now operating a steam plant. The new plants will cost in the neighborhood of $2,000,000.

Federal Power Engineer Tours the West

After visiting a number of the power-producing streams of the West, Col. William Kelly, chief engineer of the Federal Power Commission, has returned to Washington more thoroughly impressed than ever with the opportunities offered in that section to industries in which power is a relatively large factor. While he realizes that the distance of these powers from some markets offers an obstacle that cannot be overcome in many cases, yet he is of the opinion that a very large number of power-using concerns well may enter upon studies as to whether or not it would be to their advantage to undertake operations in a region where cheap power now is available and where additional power can be made available as rapidly as it is needed.

In some areas of the West, however, Colonel Kelly believes that hydro-electric development is progressing more rapidly than is justified by the probable amount of power that the region can absorb. The high price and scarcity of fuel oil at the time the water-power act was passed was an important factor in stimulating water-power development. Since that time the fuel-oil situation has become fairly satisfactory and many of the plants which expected to be forced to resort to other power have been able to continue the use of their oil-burning equipment.

Nevertheless, Colonel Kelly finds that there is general uneasiness among many users of fuel oil, partly because of prices and partly because of probable early limitations of supply. As a result he believes there will be a gradual tendency to turn to hydro-electric power.

Coming Conventions

The Electric Power Club; S. N. Clarkson, secretary, Kirby Bldg., Cleveland, Ohio. Fall meeting at Asheville, N. C., Oct. 30-Nov. 2.

National Association of Practical Refrigerating Engineers; Edward H. Fox, secretary, 5707 West Lake St., Chicago, Ill. Annual convention and exhibition at St. Louis, Mo., Nov. 1-4.

Society of Naval Architects and Marine Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

American Society of Mechanical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 4-8.

American Society of Refrigerating Engineers; W. H. Ross, secretary, 154 Nassau St., New York City. Annual meeting at New York City, Dec. 4-6.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 7-13.

Water-Power Projects

The Pacific Power and Light Co., Portland, Ore., has applied for a permit covering the development of that portion of the Snake River between Lewiston, Idaho, and Huntington, Ore. According to a preliminary survey of this territory 900,000 hp. could be developed at low water.

The Idaho Power Co. has applied to the Federal Power Commission for a license covering a 44,000-volt transmission line from American Falls to Pocatello, Idaho. This is an important line since it connects the Idaho Power Co.'s system with that of the Utah Power and Light Co. The Idaho company has a large pumping load, which during two months of the year reaches a high peak. The inter-connection will permit of much more economical handling of that load.

The Montana Power Co. plans to develop the Polson (Mont.) power site as soon as a license is obtained, according to F. W. Kerr, president of the company. Despite the use of Flathead Lake as a storage reservoir by the Columbia River Basin irrigation project, Montana Power Co. officials believe that the two projects can be harmonized.

The Snow Mountain Water and Power Co., Ukiah, Calif., has applied for a permit to construct a reservoir of 25,000 acre-ft. capacity on the middle fork of the Eel River, at Covelo, Calif., and to divert water from this reservoir through a tunnel to a second reservoir of 65,000 acre-ft. capacity on Elk Creek. A second tunnel will lead to the company's existing dam and power house.

New Publications

Air—Refrigeration—Gas. Published in English by the Verein Deutscher Ingenieure, Berlin, Germany. Paper; 9 x 12 in.; 68 pages text, 73 pages of advertisements of German firms.

This collection of illustrated papers, each by a different author, deals with piston- and turbo-compressors, fans, compressed-air locomotives, pneumatic tools, refrigeration and air separation and liquefaction. The book represents currrent German engineering practice, and it is published separately in English, French and Spanish.

Hydraulic Diagrams for the Discharge of Conduits and Canals. By Theodore Horton and the late Charles H. Swan. Third edition, published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Paper; 6 x 9 in.; 53 pages; 17 diagrams. Price, $1.

A set of diagrams, based on the formula of Ganguillet and Kutter, for use in the study of sections of the conduits and canals commonly employed in water supply, water power, sewerage and land drainage. In this edition there are three new diagrams, representing the semi-elliptical, parabolic and semi-circular sections.

The Reheating of Compressed Air. By C. R. Richards and J. N. Vedder, of the Engineering Experiment Station, University of Illinois. Bulletin No. 130, published by the University of Illinois, Urbana, Ill. Paper, 6 x 9 in.; 95 pages. Price, 50c.

When using compressed air expansively in an engine located at a distance from the compressor, it is necessary to reheat the air just before its delivery to the engine. The initial heat of compression is quickly radiated from the air receiver and pipe lines, and if the air were admitted to the engine at ordinary atmospheric temperatures, its temperature after expansion would be

so low as to cause serious trouble, due to both freezing of the moisture in the air and ineffectiveness of cylinder lubrication, with resultant loss of mechanical efficiency.

This bulletin gives the results of a series of tests made to determine the efficiencies of various methods of reheating compressed air. Performance tests were also run on an air engine under a variety of operating conditions: driven by air alone, by steam alone, and by mixtures of steam and air, the steam being injected into the air pipe as a means of reheating the air.

It was found that the efficiency of various small external combustion reheaters ranged from 16.7 to 61.5 per cent, depending upon the design, and that in the single type of internal-combustion reheater tested, the efficiency varied from 69.4 per cent, when 326 lb. of air was heated per hour, to 83.0 per cent, when 1,240 lb. was handled per hour. Coke was the fuel used for reheating.

The air-engine tests showed that the minimum amount of coke burned, per indicated horsepower per hour gained through reheating, was 0.98 lb., and per brake horsepower per hour gained, 0.90 lb. With no reheating, the mechanical efficiency fell as low as 59.8 per cent, while under the best operating conditions, using reheated air, 93.7 per cent was obtained.

The interest in air-steam mixtures developed during the investigation has led to further studies of the subject, whose results will be presented in a later bulletin.

Personals

D. C. Spencer, formerly advertising manager of American Engineering Co., Philadelphia, has joined the staff of Geo. W. Edwards Co. of that city.

John H. Irvine, assistant boiler-room engineer at the L Street Station of the Edison Electric Illuminating Co., Boston, has resigned his position to take up farming in New Hampshire. In honor of his loyal service to the company, Mr. Irvine was presented with a Ford touring car by his fellow workers.

Joseph W. Roe was re-elected president of the Society of Industrial Engineers at its ninth annual convention in New York City Oct. 18-20. Professor Roe is a member of the executive board of the American Engineering Council and head of the Department of Industrial Engineering at New York University.

Major Frederick Pope, first vice-president, New York Steam Corp. and **E. B. Powell,** consulting engineer, Stone & Webster, Inc., sailed Oct. 28 to make a study of recent developments in European power-plant practice. They expect to visit England, France and Germany and to return to this country early in December.

H. W. Geare, chief engineer of the Peter Doelger Brewery, 417 E. 55th St., New York City, has been appointed an instructor of steam engineering in the New York Evening Schools. A course in engine-room mathematics is to be given in four of the schools—two in Manhattan and two in Brooklyn—at which engineers, firemen or anyone interested in power-plant practice will be welcome.

Alfred D. Flinn has been elected director of the Engineering Foundation. Mr. Flinn is the first incumbent of the new post, created in order to meet the expanding activities of the foundation. He will retire as chairman of the Engineering Division of the National Research Council, but will continue as secretary of the United Engineering Societies, in order that the Foundation may continue intimate relations with the founder societies.

Society Affairs

Metropolitan Section, A.S.M.E., will meet on Oct. 31 at Newark, N. J., to hear a paper on "Industrial Heating Operations," by Joseph A. Doyle, of W. S. Rockwell Co.

Toronto Section, A.I.E.E., will meet on Nov. 3. C. H. Van Asperen will talk on busbar stresses at right-angle bends. On Nov. 10 Dr. J. C. McLennan will give a paper on electrons.

Pennsylvania Association No. 18, N.A.S.E., will hear a paper by Samuel B. Forse, national treasurer, entitled "Essential Knowledge that Should Be Possessed by Applicants for Engineers' License," at its regular Thursday evening meeting on Nov. 2.

Philadelphia Section, A.I.S.E.E., will hold its monthly meeting on Nov. 4 at 8 p.m., following a "Safety Switch Congress and Exhibit" at the Majestic Hotel, Broad Street and Girard Avenue, in the afternoon. P. T. Vanderwaart, electrical engineer of the New Jersey Zinc Co., will speak at the evening meeting.

Business Items

The United Electric Railways Co., of Providence, **R. I., has ordered three** 12,660-sq.ft. Bigelow-Hornsby boilers, to be fired with powdered coal.

Conveyors Corporation of America, 326 West Madison St., Chicago, Ill., has appointed the Geo. W. Fife Engineering Co., 1403 Merchants Bank Bldg., Indianapolis, as its representative for the sale of American trolley carriers in Indiana.

The Pennsylvania Crusher Co. has engaged J. B. Clark, Jr., as sales engineer. Mr. Clark, who was formerly associated with the Koppers Company of Pittsburgh, will make his headquarters at the company's New York office, 50 Church St.

The George T. Trundle, Jr., Engineering Co., 118 St. Clair Ave., Cleveland, Ohio, has appointed as vice-president John F. Price, who was formerly comptroller of the Brown Hoisting Machinery Co., Cleveland. At one time Mr. Price was vice-president of the Society of Industrial Engineers, and he is now one of its directors.

Trade Catalogs

Stokers—American Engineering Co., Philadelphia, Pa. A beautifully illustrated bulletin showing a number of installations of the Taylor Stoker.

Demand Meters—General Electric Co., Schenectady, N. Y. Bulletin No. 46,108, describing the type M-4 Demand Meter designed for use in combination with a watt-hour meter to indicate maximum demand.

Boiler Settings and Chimneys—Ballard, Sprague & Co., 200 Fifth Ave., New York City. A 20-page bulletin showing a number of boiler settings and radial-brick chimneys built by the company.

Line Shafting Equipment—The Medart Co., St. Louis, Mo. Catalog No. 43, giving list prices and dimensions of Medart shafting equipment, such as shafting, pulleys, hangers, bearings, pillow blocks, couplings, etc.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 16, 1922	Oct. 23, 1922
Pool 1,	New York	$4.75–5.75	$4.75–5.25
Smokeless,	Columbus	4.75–6.50	6.00–6.50
Clearfield,	Boston	4.00–4.50	3.50–4.00
Somerset,	Boston	4.00–4.60	3.50–4.40
Kanawha,	Columbus	4.25–4.75	4.25–4.75
Hocking,	Columbus	3.25–3.75	3.25–3.75
Pittsburgh No. 8	Cleveland	3.50–3.75	3.56
Franklin, Ill.,	Chicago	4.25–4.75	4.25–4.75
Central, Ill.,	Chicago	3.25–4.00	3.25–4.00
Ind. 4th Vein,	Chicago	4.50–4.75	4.25–4.50
West Ky.,	Louisville	2.75–3.25	2.25–2.65
Big Seam,	Birmingham	2.50–3.00	2.50–2.75
S. E. Ky.,	Louisville	3.75–5.00	3.25–4.50

FUEL OIL

New York—Oct. 26, Port Arthur light oil, 22@25 deg. Baumé, 5c. per gal.; 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago — Oct. 20, for 24@26 deg. Baumé, $1.20 per bbl.; 32@36 deg., 3½c. per gal. in tank car, f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Sept. 12, f.o.b. refinery, Pennsylvania, 36@40 deg., 6¼c.; Kentucky fuel oil, 26@30 deg., 4¼c. per gal.; Gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c.; 38@40 deg., 3¼c.; Western, 24@30 deg., $1.30 per bbl.

Philadelphia — Oct. 16, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3). 3@3¼c. per gal.; 16@20 deg. Seaboard, $1.40@$1.50 per bbl.

St. Louis—Oct. 17, f.o.b. Oklahoma 24@26 deg. $1.15 per bbl.; 26@28 deg. $1.15 per bbl.; 28@30 deg., $1.25 per bbl.; Gas oil 32@36 deg. 3¼c. per gal.; 38@40 deg. distillate, 4c. per gal.

Cincinnati—Oct. 10 for 26@28 deg. Baumé, 5½c. per gal.; 28@30, Diesel, 5¼c.; 38@40 deg., distillate, 6c. per gal.

Cleveland—Oct. 10, for 26@28 deg., Baumé, 4½c. per gal.

New Plant Construction

PROPOSED WORK

Ala., Birmingham—G. L. Miller & Co., Hurt Bldg., Atlanta, Ga., will soon receive bids for the construction of a 7 story, 133 x 240 ft. apartment hotel on South Highlands Ave. and Iroquois St., here. Estimated cost $1,300,000. J. E. Salie, Empire Bldg., Archt. Equipment detail not reported.

Ala., Birmingham — J. E. Salie, Archt., 620 Empire Bldg., will receive bids until Nov. 15 for the construction of a 7 story, 133 x 200 ft. apartment hotel, including emergency electric plant and vapor vacuum heating system, on Iroquois St. and Highland Ave., for H. M. Malony. Estimated cost $1,250,000.

Calif., Banning—The San Gorgonia Power Co. has had plans prepared for hydro electric power plant on the San Gorgonia River, including 8,410 ft. of canal 3 ft. wide, 2 ft. deep, forebay for power houses, storing 121,000 a.c. ft.; 2 power plants (1) fall of 1,774 ft. 16 sec. ft. through penstocks, (2) fall of 898 ft. total power to be developed 4,857 hp. W. L. Huber, First Natl. Bk. Bldg., San Francisco, Engr. Bids have been received for furnishing equipment for power houses.

Calif., Berkeley — The city will receive bids about Nov. 1 for the installation of 151 electroliers, including transformer tops, underground conduits, etc., in University Ave. C. L. Huggins, City Engr.

Calif., Fresno—Black's Package Co., 1025 Van Ness Ave., is having plans prepared for the construction of a 2 story, 200 ft. frontage, stores building, including refrigerating plant. Estimated cost $150,000. R. F. Felchlin Co., Bank of Italy Bldg., Engrs. and Archts.

Calif., Merced—The Merced Irrigation Dist., Bd. of Directors received bids for furnishing 2 vertical type booster plants to handle 30 sec. ft. of water against a 24 ft. head, from Llewellyn Iron Works, 1,200 North Main St., Los Angeles, with c.i. bearing $4,650, bronze bearing $4,806; Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, $7,049 to $7,302, additional charge for testing one $2,400, both $2,880; Byron-Jackson Iron Wks., 6th and Carlton Sts., Berkeley, $7,400 to $8,000 testing, $250 to $350. Noted Sept. 26.

Calif., San Francisco—The Knights of Columbus, California Council, No. 880, 1428 Golden Gate Ave., plan to build a Catholic Center Hall, auditoriums, etc., for the use of all Catholic organizations in San Francisco. Estimated cost $1,000,000.

Conn., Hartford—The Aetna Life Insurance Co., 650 Main St., is having plans prepared for an office building on Farmington Ave. Estimated cost $3,000,000. J. G. Rogers, 367 Lexington Ave., Archt. Equipment detail not reported.

D. C., Wash.—The Cosmos Theatre, A. J. Bryloski, Mgr., is having plans prepared for a theatre and office building on 13th and E Sts. NW. Estimated cost $1,750,000. C. H. Crane, 400 Huron Bldg., Detroit, Mich., Archt. Equipment detail not reported.

Ind., Crawfordsville—The city will receive bids until Nov. 6 for the construction of a 40 x 60 ft. power and light plant, including 200 ft. radial stack, 3,000 kw. turbine, service condenser, 750 hp. water tube boiler, 5,000 hp. heater, mechanical stoker and 35 kw. exciter. Estimated cost $50,000. H. C. Carroll, 511 Traction Terminal, Indianapolis, Engr. Noted Oct. 3.

Ind., Indianapolis—The Bd. of Sanitary Comrs., J. A. Craven, Pres., City Hall, will receive bids until Nov. 14 (change of date) for the construction of Sect. 3, Div. 3, and furnishing and erecting mechanical equipment for the sewage disposal plant, (1) activated sludge plant, (2) power plant auxiliary equipment, including boiler settings and breeching, coal storage bunker, coal handling equipment, power plant piping, boiler feed pumps and regulators and feed water heaters and softening system. Noted Oct. 17.

Ind., Indianapolis — The Meyer-Kiser Bank, 136 East Washington St., is having revised plans prepared for a 7 story, 87 x 197 ft. addition to its bank and office building. Estimated cost $500,000. Vonnegut, Bohn & Mueller, Indiana Trust Bldg., Archts. Equipment detail not reported.

Ind., Mishawaka—The city is having plans prepared for a 500,000 gal. reservoir, including 3 motor driven pumps. Estimated cost $40,000. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., Consult. Engrs. Noted Oct. 3.

Ia., Fort Dodge—T. G. Warden, Wahkonsa Hotel, is having plans prepared for an 8 story, 140 x 180 ft. addition to hotel. Estimated cost $700,000. Damon, O'Meare & Hills, E. Moson Bldg., Archts. Equipment detail not reported. Noted Oct. 17.

Mass., Boston—The city, Schoolhouse Dept., is having preliminary plans prepared for a high school on Dunbar Ave. Estimated cost $1,000,000. McLaughlin & Burr, 88 Tremont St., Archts.

Mich., Detroit—The Pennsylvania R.R., Broad St., Phila., Pa., in conjunction with the Pere Marquette Ry. Co., Fort St., is having plans prepared for a 1 story engine and round house, including turntable, water tower, coaling station and handling equipment on 19th St. E. V. Sommerville, 1368 Penobscot Bldg., Engr.

Mich., Flat Rock—A. Kahn, Archt., 1000 Marquette Bldg., will receive bids until about Nov. 4 for the construction of a 1 story, 242 x 761 ft. plate glass factory, including steam heating plant, here, for the Ford Motor Co., Highland Park. Estimated cost $1,500,000. The owner is in the market for miscellaneous equipment for making glass and converting it into wind shields.

Mich., Ironwood—The School Bd., A. G. Hedin, Pres., is having competitive sketches prepared for a 3 story high school. Estimated cost $700,000. Architect not selected.

Mich., Loretto—Mead & Seastone, Engrs., Journal Bldg., Madison, is receiving bids for a 1,300 hp. turbine and generator, 1,000 kva. verticle generator and exciter, etc., for the Peninsular Power Co., Nat'l. Bk. Bldg., Madison. Noted Oct. 10.

Minn., Minneapolis—The Bd. of Educ., G. F. Womrath, Bus. Supt., City Hall, will receive bids until Nov. 9 for the construction of two 3 story, 300 x 250 x 45 ft. high schools, including steam heating systems, on 5th St. S.E. and 13th Ave., and 26th St. and Emerson Ave. Estimated cost $650,000 and $600,000 respectively. Bd. of Educ. Bureau of Design, c/o E. H. Enger, 245 9th Ave. N., Archts.

Miss., McComb—The McComb Ice Co., V. G. Conner, Supt., is in the market for refrigeration machinery and equipment for proposed ice plant.

Mo., Alexandria — The Des Moines and Mississippi Levee Dist. No. 7 is having surveys made and plans prepared for the enlargement and extension of present ditch system and construction of a pumping plant to protect 12,000 acres of land from Mississippi and Fox River overflow. Estimated cost $250,000. Morgan Engr. Co., Goodwin Institute, Memphis, Tenn., Engrs.

Mo., Edgerton—The Edgerton Milling Co. is in the market for a 16 x 72 or 18 x 72 ft. horizontal boiler and 150 lb. boiler for feed heater.

Mo., St. Louis—Famous Players Missouri Corp., c/o N. Frank, Arcade Bldg., is having preliminary plans prepared for a 12 story, 120 x 130 ft. office building, including special plumbing and electric facilities for doctors, on Grand Blvd. and Lucas Ave. Estimated cost $800,000 to $1,000,000. Hilfensteller, Hirsh & Watson, 1003 Chemical Bldg., Archts. Equipment detail not reported.

Mont., Billings—W. W. Ahlschlager, Inc., Archts., 65 East Huron St., Chicago, plans to build a hotel, including steam heating system. Estimated cost $750,000. Owner's name withheld.

N. J., Jersey City—The Bd. Educ., F. Ege., Secy., is having revised plans prepared for a 3 story addition to P. S. 11, including steam heating system, on Bergen St. Estimated cost $750,000. J. T. Rowland, Jr., 100 Sip Ave., Archt.

N. J., Jersey City—The Y.M.C.A. will receive bids about Nov. 1 for a 6 story Y.M.C.A. on Bergen Ave. Estimated cost $500,000. J. Jackson, 1819 Bway, New York, Archt. and Engr. Noted Sept. 26, 1921.

N. J., Trenton—The Bd. Educ., R. C. Belville, Clk., will receive bids until Nov. 9 for a 2 story 150 x 350 ft. school for negroes on Montgomery St., estimated cost $600,000. Wm. Slack & Son, St. Regis Bldg., Archt., E. Sibley, Edgewood Lane, Palisade, Engr.; also will soon receive bids for a 2 and 3 story, 385 x 410 ft. junior high school on West State St., estimated cost $1,000,000, J. O. Hunt, 219 East Hanover St., Archt., E. Sibley, Engr.

N. J., Trenton—The Mercer Hospital, 448 Bellevue Ave., is having plans prepared for the construction of a 2 story, 56 x 68 ft. power plant. Estimated cost $18,000. Karno-Smith Co., Broad St. Bank, Archts.

N. Y., Buffalo—The Chevrolet Motor Co., West Grand Blvd., Detroit, plans to build a 1 and 2 story, 338 x 900 ft. automobile factory and loading platform, including steam heating equipment, coal storage and equipment, on East Delevan Ave., here. A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Archt.

N. Y., Buffalo—Colson-Hudson, Archts., Dun Bldg., is preparing plans and will receive bids about Jan. 2 for a 12 story, 43 x 133 ft. office building, on Washington St., for the Holling Press, 498 Washington St. Estimated cost $600,000. Equipment detail not reported.

N. Y., Buffalo—P. M. McGroff, Montreal, Que., plans to build a steel wire factory, here. Estimated cost $1,000,000. Architect not selected.

N. Y., Freeport—The Bd. of Educ. will receive bids until about Nov. 15 for a high school on Pine St. Estimated cost $600,000. W. Adams, 15 West 38th St., New York, Archt. and Engr. Equipment detail not reported. Noted Oct. 17.

N. Y., Hillcrest (Jamaica P. O.)—The Hillcrest Hotel Corp., c/o McKim, Mead & White, Archts. and Engrs., 101 Park Ave., New York, are having sketches prepared for a country club hotel. Estimated cost $1,500,000.

N. Y., New York—The N. Y. Institute for Educ. of Blind, 412 9th Ave., is having plans prepared for several 3 and 4 story buildings on Bronx and Pelham Parkways. McKim, Mead & White, 101 Park Ave., Archts. H. J. Balcom, 10 East 47th St., Engr. Equipment detail not reported.

N. Y., White Plains—The New York Orthopedic Hospital, 3rd Ave. and 23rd St., New York City, plans to build a hospital on Mamaroneck Ave., here. Estimated cost $500,000. Architect not selected.

N. D., Abercrombie—The village will soon award the contract for the construction of a waterworks system, consisting of 8,125 ft. mains, 9 hydrants, pneumatic pressure tank and pumping plant, 1,200 gal. capacity. Estimated cost $15,000.

Ohio, Cleveland—The Bd. Educ., F. G. Hogan, Dir., East 6th St. and Rockwell Ave., plans the construction of two 3 story, elementary schools, including steam heating systems, on East 108th St. and Sandusky Ave., and East 146th St. and Harvard Ave., estimated cost $900,000 and $500,000 respectively. W. R. McCornack, East 6th St. and Rockwell Ave., Archt.

Ohio, Cleveland—The city, c/o A. B. Roberts, Dir. of Public Utilities, City Hall, plans a new light plant and extensions, including erection of poles, feeders and other plant equipment to supply 15,000 more consumers. Estimated cost $10,400,000. G. Beckwith, City Hall, Engr.

Ohio, Cleveland—The Cleveland Pub. Library Bd., c/o Col. Whitlock, Kenney-Levan Bldg., will receive bids until Nov. 8 for the foundation of a 1 story, 200 x 200 ft. public library on East 3rd and Superior Sts. Estimated total cost $4,000,000. Walker & Weeks, 1900 Euclid Ave., Archts. Equipment detail not reported.

Ohio, Cleveland — The Moreland Development Co., c/o J. Kirty, Discount Bldg., is having plans prepared for the construction of a 4 and 5 story, 108 suite apartment building, including steam heating system, on North Moreland Blvd. and Kemper Rd. Estimated cost $1,000,000. A. W. Harris, Discount Bldg., Archt.

Ohio, Cleveland — The Stratford Court Development Co., c/o J. Kirby, Discount Bldg., is having plans prepared for the construction of a 3 story, 150 x 600 ft. stores and apartment building, including steam heating system, on Shaker Blvd. Estimated cost $1,000,000. A. W. Harris, Discount Bldg., Archt.

Ohio, Dayton — T. Horobin, 59 Pioneer St., plans to build a 6 story, 60 x 300 ft. apartment building on Forest Ave. Estimated cost $800,000. Private plans. Equipment detail not reported.

Okla., Cement—The city is having plans prepared for the construction of water main extensions, electrical distribution system and extensions and improvements to electrical power plants. Estimated cost $30,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs.

Okla., Tecumseh—C. Polaski is in the market for ice making machinery.

Ore., Bend—The Bend Water, Light & Power Co., T. H. Foley, Vice-Pres., has applied to P. A. Cupper, State Engr., for permission to use 5,000 sec. ft. of water from the Deschutes river, for power purposes, construction to include a concrete dam, 270 ft. high, 800 ft. long on top, 120 ft. long at the base, to develop 106,000 hp., also power house, penstocks, power line, turbines, generators, transmission line and other accessories. Bids will be received early in the spring. V. H. Reineking, Spaulding Bldg., Portland, Engr. Owner is in the market for power and electrical equipment.

Ore., Canby—J. H. Balling, Elec. Engr., 512 Hancock St., Portland, is making surveys and preparing plans for an electric lighting system for the city; bids will be received in about 30 days.

Ore., Portland — The Burke Fish Co., Front and Pettygrove Sts., is in the market for a 40 hp. boiler with fire box and grater.

Pa., Altoona—The Altoona & Logan Valley Elec. Ry. Co., S. S. Crane, Gen. Mgr., plans to build a 66 x 70 ft. addition to power plant, 1,500 kw. capacity, including 3,500 hp. cross compressing condensing engine, surface condensor and large separator, on 6th Ave. and 32nd St. Estimated cost $25,000. F. D. Hain Co., 203 Coleridge Ave., Llyswen, Engrs.

Pa., Altoona—The School Dist., Bd. of Dirs., received low bids for the construction of a 3 story, 224 x 232 ft. junior high school on 6th ave. and 15th St., from H. J. Conrath Co., Ariel Bldg., Erie, $551,714. Prahl Constr. Co., Marine Bk. Bldg., Erie, $556,462. P. H. Kelly Co., Presser Bldg., Phila., $564,340; heating, from Sanitary Engr. Co., Anderson, Ind., $116,947. Freyn Bros., 31 West Michigan Ave., Indianapolis, Ind., $126,752. Becker Seedel Co., 324 Prospect St., Cleveland, Ohio, $129,000.

Pa., Butler—E. L. Tilton and E. P. Mellon, Archts., 52 Vanderbilt Ave., New York, will receive bids until Nov. 15 for the construction of a 3 story addition to hospital on Brady St. for the Butler Memorial Hospital, c/o T. Shufflin. Estimated cost $500,000. Equipment detail not reported. Noted Apr. 5, 1921.

Pa., Oil City—The Bd. of Educ. will receive bids until Dec. 1 for the construction of a Junior High School. Estimated cost $500,000. E. E. Bailey, Archt. Equipment details not reported.

Pa., Phila.—The J. B. Stetson Co., 5th St. and Columbia Ave., is having plans prepared for the construction of an 8 story, 62 x 75 ft. factory, a 1 story, 114 x 114 ft. garage and workshop and a 1 story, 75 x 124 ft. machine and repair shop, including steam heating system on 4th St. and Columbia Ave. J. O. Potts, 5th St. and Montgomery Ave., Archt.

Pa., Phila.—J. T. Windrim, Archt., Commonwealth Trust Bldg., is receiving bids for the construction of a 4 story, 57 x 110 ft. electrical laboratory, including indirect heating system, on 19th and Cherry Sts., for the Franklin Institute, 15 South 7th St. Estimated cost $250,000.

Pa., Pittsburgh—The city, W. A. Magee, Mayor, will soon award the contract for the construction of a 4 story addition to hospital and a power plant at Leech Farms. Estimated cost $179,000. J. P. Brennan, Municipal Bldg., N. S., Archt.

Pa., Saxton—The Penn Central Light & Power Co., Altoona, plans to issue $80,000 bonds for new light and power plant here. Noted Aug. 1.

R. I., Providence — Brown University, Prospect St., plans to build a dormitory and club house. Estimated cost $750,000.

Tenn., Elizabethton — The W. Marsh Lumber Co. is in the market for boiler, engine and auxiliary equipment in its power house.

Tenn., Memphis—The Memphis Artesian Water Dept., Bd. of Comrs., will receive bids until Nov. 24 for the construction of superstructures and furnishing and installing machinery for the new water supply works as follows: Contract 7, superstructures, chimney and filter equipment; Contract 8, coal and ash handling system; Contract 9, three 9 m.g.d. low head, centrifugal pumps direct connected to reaction water turbines; Contract 10, two 100 kw. direct connected unaflow engine generator sets and switchboard.

Tex., Dallas—The Dallas Power & Light Co. is having plans prepared for the construction of a 15,000 kw. steam power plant on Flynn St. Estimated cost $2,180,000. J. Oram, Ch. Engr.

Tex., Dallas—The Leachman Dallas Steam Laundry & Dye Works, A. Leachman, Purch. Agt., 2009 Hickory St., is in the market for a 15 hp. motor.

Tex., Granger—L. C. Salen is in the market for a 12 to 18 hp. horizontal boiler.

Va., Richmond—The Virginia Ry. & Power Co., 7th and Franklin Sts., plans to install a 20,000 kva. generating unit. A 110,000 volt transmission line will be built from Suffolk to Norfolk, estimated cost $1,000,000.

Wash., Seattle—The United Hotels Co., 25 West 45th St., New York, is having sketches prepared for the construction of a hotel, here. Estimated cost $3,000,000. George B. Post & Son, 101 Park Ave., New York, Archts. and Engrs.

Wis., Milwaukee—The Dept. Pub. Wks., R. E. Stoelting, Comr., received bids for furnishing and installing boilers in the Riverside pumping station, foot of Chambers St., as follows: Industrial Htg. & Eng. Co., 143 Oneida St., (a) $67,500, (b) $70,500, (c) $71,300 (d) $72,500; Heine Safety Boiler So., 5319 Marcus St., St. Louis, Mo., $71,595, $74,361, $76,810, $74,576; Wickes Boiler Co., 512 North Water St., Saginaw, Mich., $74,807, $74,692, $74,291, $74,347. Noted Oct. 3.

Wis., Milwaukee—M. Tullgren & Sons, Archts., 425 East Water St., are receiving bids for about 1,300 ton of structural steel and about 25,000 cu.yd. of excavation for the construction of a 7 story, 150 x 205 ft. theatre and office building on Grand Ave. and 6th St. for the Grand & Sixth Bldg. Co., Inc., c/o O. Brachman, 425 East Water St. Estimated total cost $2,000,000. Equipment detail not reported. Noted Oct. 3.

Ont., Paisley—The city council, A. Forrester, Reeve, plans the construction of a power plant and dam on the Little Saugeen River, here. Estimated cost $60,000. A. James, 36 Toronto St., Toronto, Engr. Prices wanted on materials and equipment.

Ont., Shedden—The city c/o W. Miller, plans the construction of an electric lighting and power distribution system, including line from here to St. Thomas. Estimated cost $40,000.

CONTRACTS AWARDED

Ala., Birmingham—The city awarded the contract for the construction of a 2 story, 140 x 200 ft. market house on 3rd Ave. and 23rd St. to the Inglenook Constr. Co., Realty Bldg. Estimated cost $195,000. Complete refrigerating plant to be installed.

Calif., Knights Landing (Grafton P. O.) —The Meek Estate has awarded the contract for the construction of a pumping plant in Reclamation Dist. 730 to L. F. Youdall, Commercial Savings Bk. Bldg., Stockton, plant $16,650, equipment $5,779. Bryon Jackson pumps and General Electric motors will be installed. Noted Oct. 17.

Conn., Bridgeport—The Huber Ice Cream Co., 800 Seaview Ave., awarded the contract for a 3 story, 60 x 102 ft. addition to ice cream factory, including steam heating system, on Eagle St. and Seaview Ave. to the T. J. Pardy Constr. Co., 1381 Seaview Ave. Estimated cost $100,000. Owner is in the market for ice making machinery. Noted Sept. 19.

Conn., Hartford — The Hartford Electric Light Co. awarded the contract for the installation of a 20,000 kw. turbine and condenser in the new South Meadow Station, to Stone & Webster, Inc., 147 Milk St., Boston. Estimated cost $700,000.

Fla., Apalachicola—The city awarded contracts for installing additional equipment in water and electric light plant as follows: two 200 hp. Skinner Universal uniflow engines and two 150 kva. General Electric generators to E. T. Scott & Co., Atlanta, Ga., $15,000; switchboard to the General Electric Co., Graham Bldg., Jacksonville, $2,000; one 300 g.p.m. and one 25 g.p.m. motor driven De Laval centrifugal pumps to Burford Hall & Smith, 3rd Nat'l. Bk. Bldg., Atlanta, Ga. Noted Oct. 3.

Ill., Chicago—E. J. Brach & Sons, 215 West Ohio St., awarded the contract for the construction of a 3 story, 100 x 300 ft. candy factory, including steam heating system, on Kinzie and Cicero Sts., to the Henry Erickson Co., 139 North Clark St. Estimated cost $1,000,000. Noted Oct. 24.

Ill., Chicago—E. L. Ohrman, c/o J. E. O. Pridmore, Archt., 38 South Dearborn St., awarded the contract for the construction of a 10 story, 160 x 348 ft. hotel, first unit, including steam heating system, on Broadway and Sheridan Sts., to Caldwell & Son Co., 508 State Savings & Trust Bldg., Indianapolis, Ind. Estimated total cost $5,000,000.

Ill., Grand Tower — The Middle West Power Co. of Illinois awarded the contract for the construction of the foundations for a large electric power house, consisting of sinking 48 open concrete caissons from 8 to 74 ft. in diameter, near here, to the Union Bridge & Constr. Co., 903 Sharp Bldg., Kansas City, Mo. Estimated cost $350,000.

Ind., Fort Wayne—The Keenan Hotel Co. awarded the contract for the construction of a 14 story, 120 x 150 ft. hotel on Harrison St., to the Fleisher Constr. Co., 608 Builders' Exchange, Minneapolis, Minn. Estimated cost $1,000,000. Equipment detail not reported. Noted July 11.

Ind., Hammond—The Bd. of Pub. Wks. awarded the contract for the construction of a pumping station to supply new north and south side systems, to Ahlborn & Bates, $227,324. Noted Aug. 29.

Ind., Indianapolis — The Bd. of Health awarded the contract for the construction of a 3 story, 136 x 144 ft. and 4 story, 40 x 197 ft. hospital addition and nurses' home, to the Cornell Engineering Co., 2611 Cornell St., $320,000. Equipment detail not reported.

Ia., Carroll—The city awarded the contract for the construction of a sewage system, consisting of sanitary sewers, 9,000 ft. of 8 in. sewer, two pumping stations, 8 combination manholes, 17 manholes and slush tanks, to Sorenson Drainage Co., Slayton, Minn. Estimated cost $22,174.

Ia., Sioux City—The Hanford Produce Co., 1st and Court Sts., awarded the contract for the construction of a 3 story, 100 x 150 ft. cold storage warehouse and ice plant on 1st and Virginia Sts. to the Younglove Constr. Co., United Bank Bldg. Estimated cost $100,000.

N. J., Kearny—The state awarded the contract for alterations and a new heating plant at the Soldiers' Home here to W. G. Royer, 510 Stuyvesant Ave., Trenton. Estimated cost $12,012.

N. Y., New York—The Allerton House, Inc., 132 East 57th St., will build by separate contracts a 16 story hotel, including steam heating system, on Madison Ave. and 38th St. Estimated cost $2,250,000.

N. Y., New York—M. Paterno, 200 West 72nd St., will build, by separate contracts, a 14 story, 100 x 135 ft. apartment building on 89th St. and Park Ave. Estimated cost $850,000. R. Candella, 200 West 72nd St., Archt. and Engr. Equipment detail not reported.

Ohio, Cleveland—The Moreland Development Co., c/o J. Kirty, Discount Bldg., awarded the contract for the construction of a 4 and 10 story, 38 x 800 ft. apartment building on Shaker Blvd. and Coventry Rd., to the Hunting Constr. Co., Discount Bldg. Estimated cost $3,000,000. Steam heating system will be installed.

Pa., Phila.—The Insurance Company of North America, 232 Walnut St., awarded the contract for the construction of a 20 story office building on the Parkway, to Stone & Webster, Inc., 147 Milk St., Boston. Estimated cost $4,000,000. Equipment detail not reported. Noted Oct. 3.

Tenn., Memphis—The Al Chymia Temple, Mystic Shrine Bldg. Com., B. M. White, Chn., awarded the contract for the construction of a 10 story, 50 x 150 ft. office and club building on Front and Monroe Sts., to Kaucher, Hodges & Co., Exchange Bldg., $600,000. Steam heating system will be installed. Noted Sept. 26.

Tenn., Memphis — The Tri-States Hotel Co. awarded the contract for the construction of a 15 story, 358 room hotel on North Main and Adams Sts., to the Jas. Alexander Constr. Co., 388 North Front St. Estimated cost $1,500,000. Steam heating system to be installed. Noted June 21, 1921.

Tex., Dallas—The Stickle Lumber Corp., Maple Ave., will build a 1 story, 100 x 200 ft. flooring mill and a 60 x 60 ft. power plant. Estimated cost $75,000. R. O. Jameson, American Nat'l Bank Bldg., Consulting Engineer. Equipment detail not reported. Noted May 30.

Wis., Manitowoc—The Aluminum Goods Mfg. Co. awarded the contract for a 24 x 54 ft. boiler house to W. W. Oeflein, Inc., 86 Michigan St., Milwaukee. Estimated cost $25,000. Owner is in the market for boilers and steel stack.